Industri-Plex
4.6.2
14994

Woburn Environmental Studies

PHASE II REPORT

Volume 2

FEASIBILITY STUDY

PREPARED BY: STAUFFER CHEMICAL COMPANY

CONSULTANTS: ROUX ASSOCIATES, INC.
MALCOLM PIRNIE, INC.

DATE: APRIL 1985

Stauffer Chemical Company
Westport, Connecticut 06881 / Tel. (203) 222-3000 / Cable "Staufchem"

May 8, 1985

Mr. Richard T. Leighton
U.S. Environmental
Protection Agency
Waste Management Division
Site Response Section
J.F. Kennedy Federal Building
Boston, MA 02203

Dear Mr. Leighton:

Attached are corrected pages to be inserted in Appendix G of the Woburn Feasibility Study dated April, 1985. The following pages are attached: 3, 6, 7, 8, modified Tables II, III, IV and the cover sheet to be inserted. Please remove those pages and insert the new pages.

Very truly yours,

Daniel McGrade (dm)

Daniel McGrade
Mgr., Environmental Control

DMcG:dm

Attachments

WOBURN ENVIRONMENTAL STUDIES
FEASIBILITY STUDY

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WOBURN ENVIRONMENTAL STUDIES
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EXECUTIVE SUMMARY

SECTION I

1. PURPOSE OF THE FEASIBILITY STUDY

The purpose of the Feasibility Study is to define the Woburn site environmental and health problems and remedial objectives, evaluate all applicable remedial action alternatives, and to recommend a cost effective remedial action. The study considers technical feasibility, environmental effectiveness, costs, and relevant regulations, standards and criteria in evaluating and selecting the remedial actions.

2. SITE OVERVIEW

The Woburn Industri-Plex 128 Superfund "National Priority List" site is a 244 acre parcel of land located in an industrial park in the north-west corner of Woburn, Mass. Numerous manufacturing operations were conducted on this site from 1853 to the present including, but not limited to, production of sulfuric acid, organic chemicals, chemicals for the local tanning and paper making industries, arsenical pesticides and glue from animal hides. Wastes containing arsenic, chromium, lead, zinc and copper as well as raw and chrome tanned animal hides were deposited on the site as fill for low spots or in settling lagoons.

From 1853 - 1969, a number of owners operated chemical and other manufacturing facilities including operations purchased by Monsanto and Stauffer Chemical Company. Stauffer manufactured glue from waste hides.

In 1969, Mark Philip Trust purchased the property and began developing the site by excavating and piling wastes in wetlands and under high voltage power lines on the northerly edge of the property. Also during this period, "unauthorized" dumping was reported in local papers. Odor complaints were lodged by nearby residents and communities. The Environmental Protection Agency (EPA) and the Massachusetts Department of Environmental Quality and Engineering (DEQE) halted further development, performed preliminary site evaluations and secured the site.

In 1980, the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) was signed into law. Stauffer Chemical Company, in May 1982, entered into a consent agreement with EPA and DEQE to investigate the site and evaluate remedial actions.

The site Remedial Investigation Report was submitted in September 1984 and is available from the EPA Region I. The investigation included extensive soil and waste deposit sampling and analysis, groundwater and surface water monitoring, characterization of site air emissions and odors, a waste deposit characterization, an environmental impact assessment and an endangerment assessment. It was reported that no waste deposits or soil contamination were found on the 120 acres East of Commerce Way. About 50 acres of soil contaminated with heavy metals and 20 acres of hide waste piles and burials were located on the 124 acres West of Commerce Way and in the north west corner of the site. From the findings of the investigation and subsequent environmental impact and endangerment assessments, the site problems were identified as follows:

- Groundwater contaminated with parts per million (ppm) levels of benzene and toluene that has the potential to migrate to the closed Woburn municipal drinking wells and exceed EPA's Suggested No Adverse Response Level (SNARL), recommended by the National Academy of Sciences (NAS), for benzene at this point.
- Odors caused by emissions of hydrogen sulfide (H_2S) gas generated by the anaerobic bacterial degradation of the East Hide Pile.
- Potential direct human contact exposure to levels of arsenic (As), lead (Pb), and chromium (Cr), in the near surface soil, greater than the calculated safe levels (Appendix F).

3. REMEDIAL OBJECTIVES

Remedial Objectives were established to remedy the problems listed above and minimize the creation of other problems as follows:

- Prevent adverse impacts on downgradient groundwater users that might be caused by site contaminated groundwaters.
- Assure site contaminants have no significant detrimental impact on onsite and downstream surface water uses.
- Reduce potential exposure to potentially harmful levels of site contaminants via direct contact.
- Assure that air emissions attributable to the site waste deposits do not create nuisance odors or health hazards or exceed standards.
- Minimize restriction of land uses.

4. REMEDIAL ALTERNATIVES

The Feasibility Study considered all potentially applicable remedial alternatives. The alternatives are described, screened and ranked in Section VI of this report prepared by Malcolm Pirnie. The screening and ranking were based upon the technical feasibility, environmental effectiveness, ability to meet relevant standards and criteria, constructability, reliability, time to implement, and acceptability to regulatory authorities. Cost estimates were prepared for each alternative by Stauffer Chemical Company and were considered in final selection of remedial actions (Appendix I). The remedial actions were evaluated in relation to site problems and remedial objectives. A large number of these alternatives were rejected because of their inability to meet one or more of the criteria specified above. The viable remedial alternatives evaluated for each site problem are as follows:

Groundwater Contaminated with Benzene and Toluene	Estimated Capital and O/M Costs
• Pump at the Site Boundary, Discharge to MDC (Evaluated in September 1984 Submission)	$ 200K
• Pump Localized High Concentrations of Benzene/Toluene, Treat, Discharge to the Aquifer Upgradient	$ 930K
• Pump Groundwater at the Site Boundary, Treat, Discharge to the Surface Water	$ 3,650K
• Pump Groundwater Downgradient of Site at Leading Edge of the Benzene Plume, Treat, Discharge to Surface Water	$11,000K

Odor Control East Pile

• Cap East Pile with 6" Clay, Install Gas Collection System, Disperse to Atmosphere (Evaluated in September, 1984 Submission)	$ 1,900K
• Cap with 20 mil PVC and 30" of Soil	$ 1,900K
• Cap East Pile with 20 mil PVC, Install Gas Collection System, Treat Gas Emissions Prior to Discharge	$ 2,700K

Contaminated Soil/Waste Deposits

• 2 Foot Clay Cap About 70 Acres	$23,600K
• 20 mil PVC Cover About 70 Acres	$11,200K
• 30 inch Soil Cover About 40 Acres	$ 6,500K
• 6" Soil Cover/Fence/Deed Restrictions (Evaluated in September, 1984 Submission)	$ 1,900K
• Consolidate about 50 acres to 15 acres PVC Cover With Backfilling	$19,000K
• Consolidate about 50 acres to 15 acres PVC Cover Without Backfilling	$11,000K
• Relocate to Onsite RCRA Landfill	$96,000K

5. RECOMMENDED REMEDIAL ACTIONS

The recommended remedial action is as follows:

	Estimated Capital and O/M Costs
• Pump Groundwater at Site Boundary, Treat, Discharge to Surface Water	$ 3,600K
• Cap East Pile with 20 mil PVC Cover, 30" Soil/Sand/Fill, Collect and Treat Gases with Activated Carbon	$ 2,700K
• Place 30" Soil Cover over Areas of Potential Direct Contact Hazard	$ 6,500K
Total Estimated Cost of Remedial Action	$12,800K

This remedial action will achieve the remedial objectives set forth in Section III and protect the public health and environment. Specifically, implementation of this recommendation will prevent benzene and toluene in the groundwater from reaching the closed Woburn municipal wells (G & H) at levels exceeding EPA's Suggested No Adverse Response Level (SNARL) of 6.7 ppb, (Appendix B). Similarly, the discharge to the surface water will employ the following treatment technologies to assure surface water quality and drinking water standards and criteria are met (Table 2-2): air stripping to remove benzene and toluene and biological treatment to remove BOD. Odor control is included to assure nuisance odors will not be produced. Air emissions from the groundwater treatment will meet the calculated ambient air standards and be protective of the public health.

Odors attributable to decomposing hides in the East Hide Pile will be eliminated by removal of the causes of odor incidents by stabilizing pile sides, draining wetlands, rerouting surface runoff and installing an impermeable synthetic cover. In addition, a perforated pipe gas collection system and activated carbon treatment of the gases will be employed to assure odors are eliminated.

Direct contact with potentially harmful levels of arsenic (As), chromium (Cr), and lead (Pb) in site soil will be eliminated by covering those areas with 30" of clean soil. Potential erosion of contaminants to surface will be reduced by this cover and rerouting of the surface waters. The remote threat of rainwater infiltration causing migration of heavy metals to G & H wells in excess of drinking water standards, is eliminated by the groundwater remedy which captures all groundwater leaving the site.

This recommended remedial action, while cost effective and environmentally sound, does not fully satisfy one detail of EPA's Resource Conservation and Recovery Act (RCRA) closure requirements of a hazardous waste site. This requirement is use of a 24 inch thick clay cap over the entire site to prevent leaching of soil contaminants to groundwater. Such leaching in harmful quantities was not identified as a Woburn site problem however, and thus, such closure was judged unnecessary.

6. OTHER ALTERNATIVES

The other viable alternatives were not selected for the following reasons:

- Some did not provide sufficient certainty of achieving environmental objectives (e.g., pumping localized high concentrations of benzene, only capping East Pile).
- The substantially higher costs did not provide measureably significant increases in the protection of public health or environment (i.e., impermeable caps, consolidation, RCRA onsite landfill).
- Some were unacceptable to local and state regulatory authorities (i.e., discharge to MDC and dispersion of odors).
- Some severely restricted future development of the site (i.e., impermeable caps).
- A few would cause disruption of community and area business with heavy truck traffic and extended time periods to implement (e.g., consolidate with backfill).

The report that follows describes in more detail the site history, present conditions, environmental and health assessments, remedial alternatives, and the basis for selection of the recommended actions.

WOBURN ENVIRONMENTAL STUDIES
FEASIBILITY STUDY

INTRODUCTION

SECTION II

1. SITE SETTING

The Woburn Industri-Plex 128 site is a 244 acre parcel of land located in an industrial park in the northwest corner of Woburn, Massachusetts. It is located near the intersection of two major highways, RT. 93 and RT. 128. A rapidly growing high technology industry is developing along RT 128. (Figure A on following page).

The 244 acre parcel of land includes some occupied office buildings and industries, railroad tracks, power line rights-of-way, and old abandoned manufacturing facilities. Most of the property is owned by Mark Phillip Trust, an industrial developer who has claimed bankruptcy, and a few other parties anxious to develop the property.

The site has a number of small surface water streams including the Aberjona River and its tributaries which discharges to the Mystic River. Adjacent to the site is Woburn's sanitary landfill. Wastes are piled under the powerlines and buried on the property. There is no evidence of waste drum disposal. Distressed vegetation is noticeable and evidence of a waste disposal lagoon remains. The site map on the following pages identifies the features. (Figure B).

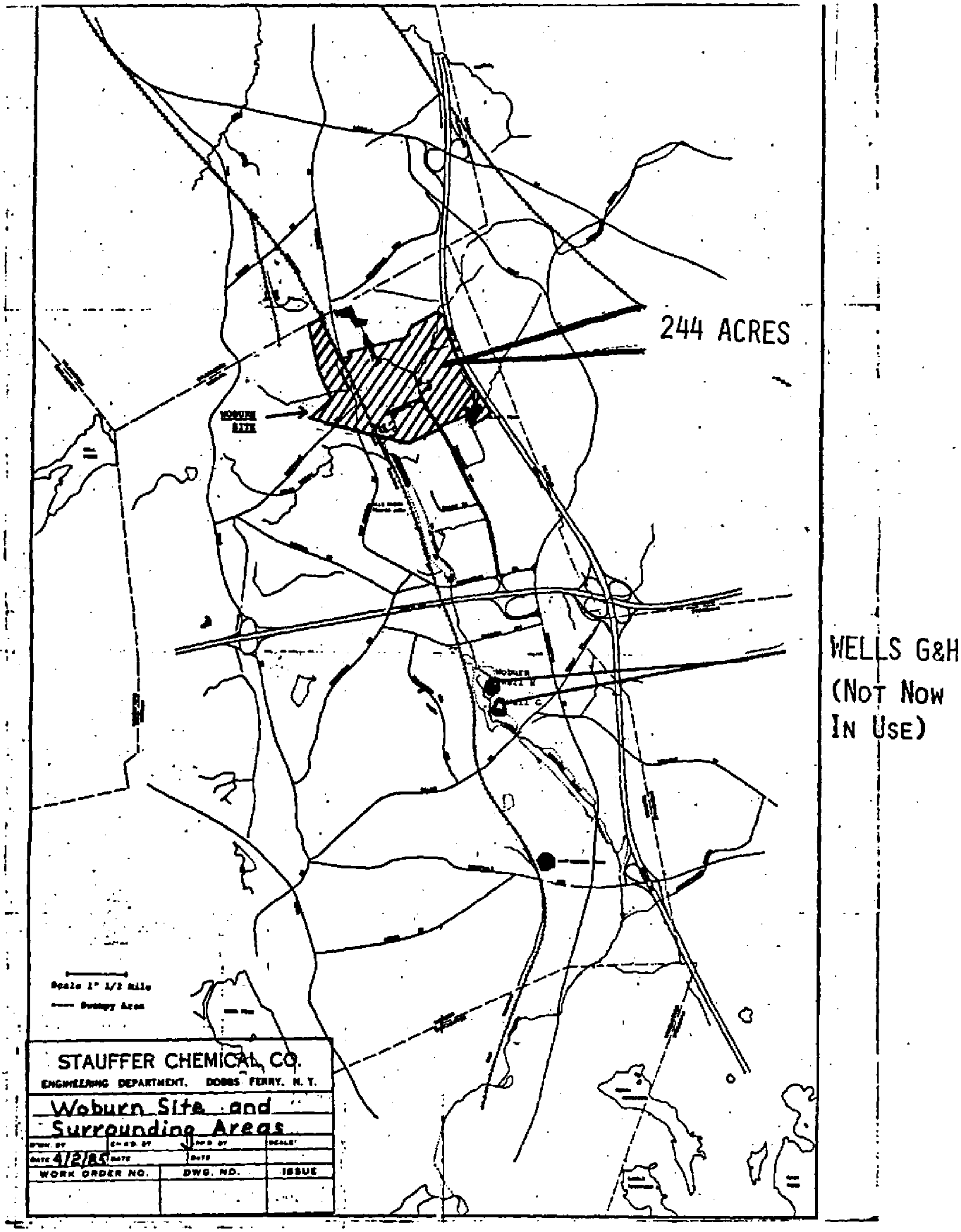

244 ACRES
WELLS G&H
(NOT NOW
IN USE)
Woburn Site
Scale 1" 1/2 Mile
Swampy Area
STAUFFER CHEMICAL CO.
ENGINEERING DEPARTMENT, DOBBS FERRY, N. Y.
Woburn Site and
Surrounding Areas
DATE 4/2/85
WORK ORDER NO.
DWG. NO.
ISSUE

FIGURE A

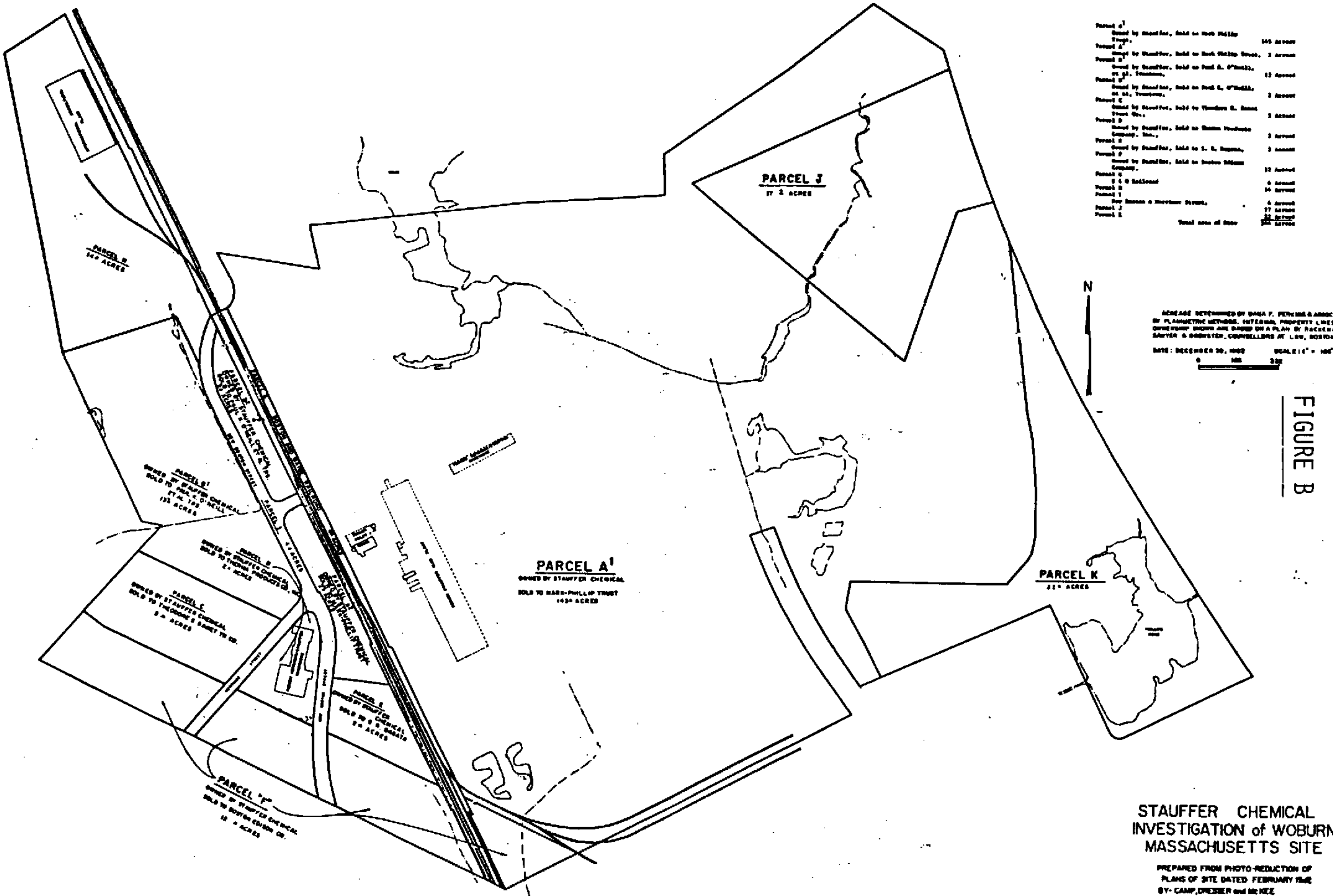


FIGURE B

STAUFFER CHEMICAL
INVESTIGATION of WOBURN
MASSACHUSETTS SITE

PREPARED FROM PHOTO-REDUCTION OF
PLANS OF SITE DATED FEBRUARY 19
BY- CAMP, DRESSER and McKEE
SCALE - 1" = 400'

2. SITE HISTORY

Various manufacturing facilities operated on the Woburn site from 1853 to 1968. A complete site history of ownership and activities was reported in the Phase I site investigation. The following paragraphs briefly summarize the history.

Robert Eaton founded and operated the Woburn Chemical Company from 1853 to 1863. The Merrimac Manufacturing Company purchased and merged the Woburn Chemical Company into the Merrimac Chemical Company in 1863. The Merrimac Chemical Company produced sulfuric acid and other chemicals for textiles, tanners and paper makers and was the largest U.S. producer of arsenic pesticides.

In 1915, Merrimac established a subsidiary, the New England Manufacturing Company with facilities in Woburn. New England Manufacturing produced organic chemicals, including phenol, benzene, picric acid and toluene. In 1929, Monsanto Chemical Company purchased the Merrimac operations. By 1931, all Merrimac Chemical operations in Woburn were terminated. A list of the chemicals produced and used at the site from 1853 to 1931 is listed in the Remedial Investigation Report, Appendix II, Tables 2.1-2.7.

In 1934, New England Chemical Company purchased approximately 370 acres formerly owned by Merrimac Chemical in Woburn. By 1935, New England constructed and operated a plant that manufactured glue from waste raw and tanned hides. New England Chemical was purchased by Consolidated Chemical Company in 1936. Consolidated was purchased by Stauffer Chemical Company in the late 1950's. Stauffer operated the glue plant until 1969. A list of the chemicals used at the glue manufacturing plant from 1935-1969 is listed in the Remedial Investigation Report, Appendix II, Table 3.

Stauffer owned 184 acres of the 244 acre Woburn site. In 1969, about 149 acres of Stauffer's 184 acres was sold to the Mark Phillips Trust and the remaining 35 acres were sold to others.

In the 1970's, Mark Phillips Trust began developing the site. Waste deposits and soil were excavated and piled above ground on the northerly border of the property. Noxious odors were generated and nearby residential areas registered complaints. EPA and the DEQE issued a cease and desist order to Mark Phillips Trust.

In 1980, the Comprehensive Environmental Response and Liability Act (commonly called Superfund) was enacted. The purpose of CERCLA was to provide EPA with resources and authority to cost effectively clean up hazardous waste disposal sites.

In May 1982, Stauffer Chemical Company signed a Consent Agreement with EPA and the DEQE to investigate the site environmental conditions and prepare a report evaluating and recommending appropriate remedial actions. Stauffer completed a comprehensive site investigation which was conducted over a two year period. A Remedial Investigation Report was submitted on September 11, 1984 and is on file at EPA Region I Offices. The report documents the work performed, sampling and analytical procedures and methods, site hydrogeology, environmental impacts on groundwater, surface water and air and the extent and nature of waste deposits and soil contamination.

3. GENERAL DESCRIPTION OF SITE HYDROGEOLOGY

The Woburn Site is underlain by a thin veneer of unconsolidated sediments overlying crystalline bedrock. Most of the unconsolidated deposits (fill, peat and till) have poor water transmitting capabilities. The exception is the well-sorted outwash sands which are very permeable but are thin and not present under the entire site. However, south of the site a pre-existing bedrock valley has been filled with these outwash sands and they are thick enough to form an aquifer which will yield large quantities of water to supply wells. The crystalline rock underlying and bordering the valley is of low permeability and is not considered an aquifer.

Most groundwater flowing under the site originated as precipitation on the site. Very little groundwater enters from the north, east and west because of the presence of dense, crystalline rock. Groundwater flows from areas of higher elevation (i.e. bedrock knobs) to discharge into surface-water bodies on the site or into the buried valley aquifer. The buried valley aquifer also receives recharge from the higher terrain to the east and west, precipitation falling on the valley itself, and hydraulically connected surface-water bodies. Because the sands filling the valley are permeable, groundwater in the buried valley will flow at a rate of approximately one foot per day. Groundwater flow rates elsewhere on the site are variable but generally less than one foot per day due to the presence of lower permeable sediments such as till.

Groundwater flow is southward in the buried valley. Figure C illustrates the groundwater flow pattern as water table contour lines with groundwater flow perpendicular to the lines. Closed municipal supply wells G and H tap the buried valley aquifer approximately 1.25 miles below the site and are potential receptors. Ultimately, if no pumping wells are present, all groundwater in the buried valley will discharge into the Mystic River at least six miles south of the site. Some shallow groundwater will discharge along the way into the Aberjona River to maintain base flow during periods of low precipitation.

The Remedial Investigation Report provides a more detailed description of the site hydrogeology.

4. PLANNED USE OF FACILITY

The Woburn Industri-Plex 128 site is zoned for industrial and commercial use. Developers and town officials planned to expand the adjacent industrial park and offices to the undeveloped areas. Residential use is not likely since the site is surrounded by industrial and commercial operations.

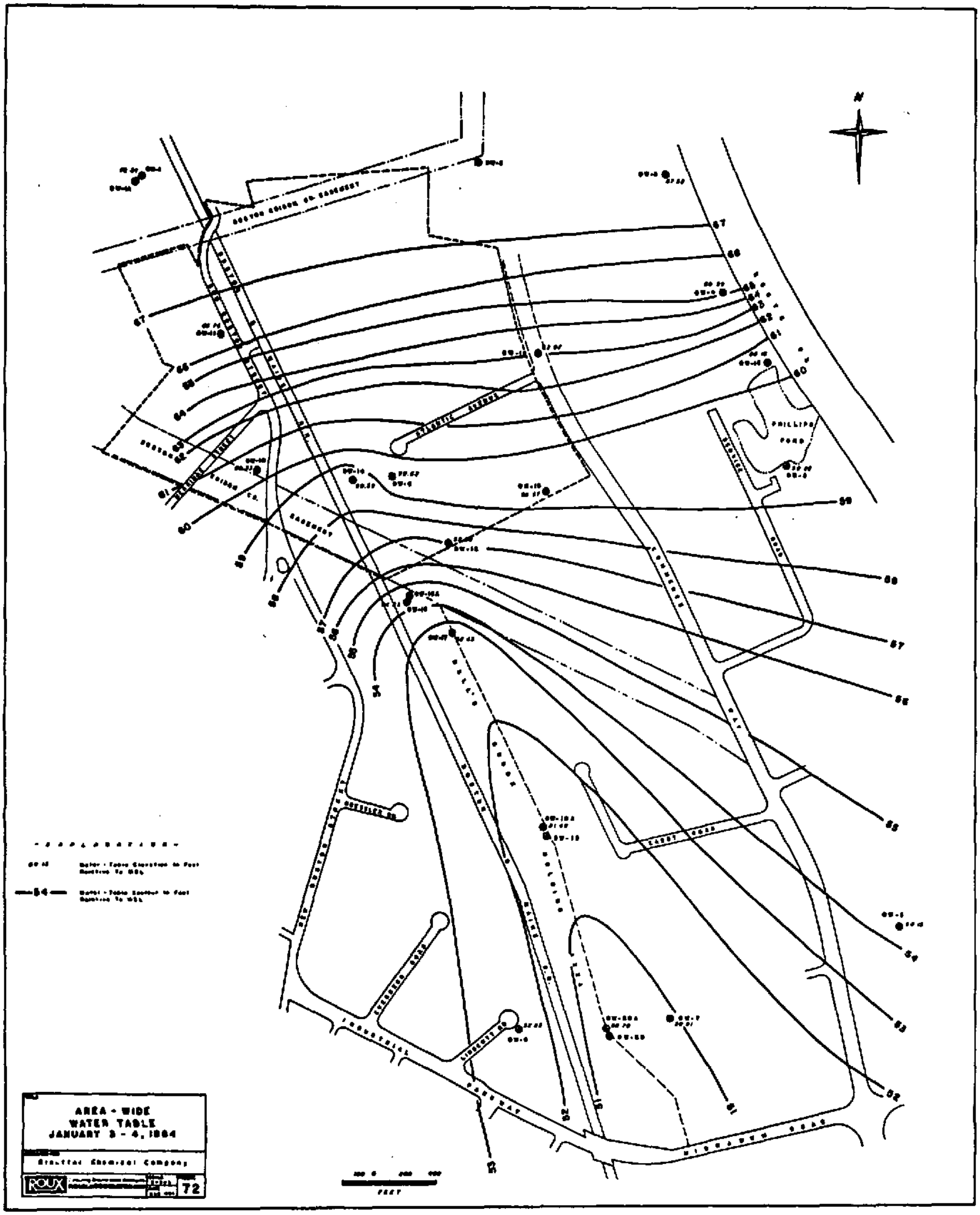

N
PHILLIPS POND
AREA - WIDE
WATER TABLE
JANUARY 3 - 4, 1984
ROUX
72

FIGURE C

NATURE AND EXTENT OF PROBLEM

SECTION III

1. DESCRIPTION OF WASTES

The Woburn site investigation (Remedial Investigation Report) found deposits of waste animal hides and heavy metals and soil contaminated with elevated levels of heavy metals on about 90 acres west of Commerce Way. Drums, tanks or liquids were not found during the extensive investigation.

Organic chemical deposits were not located on the site. Soil sampling found no evidence of significant contamination with organic chemicals.

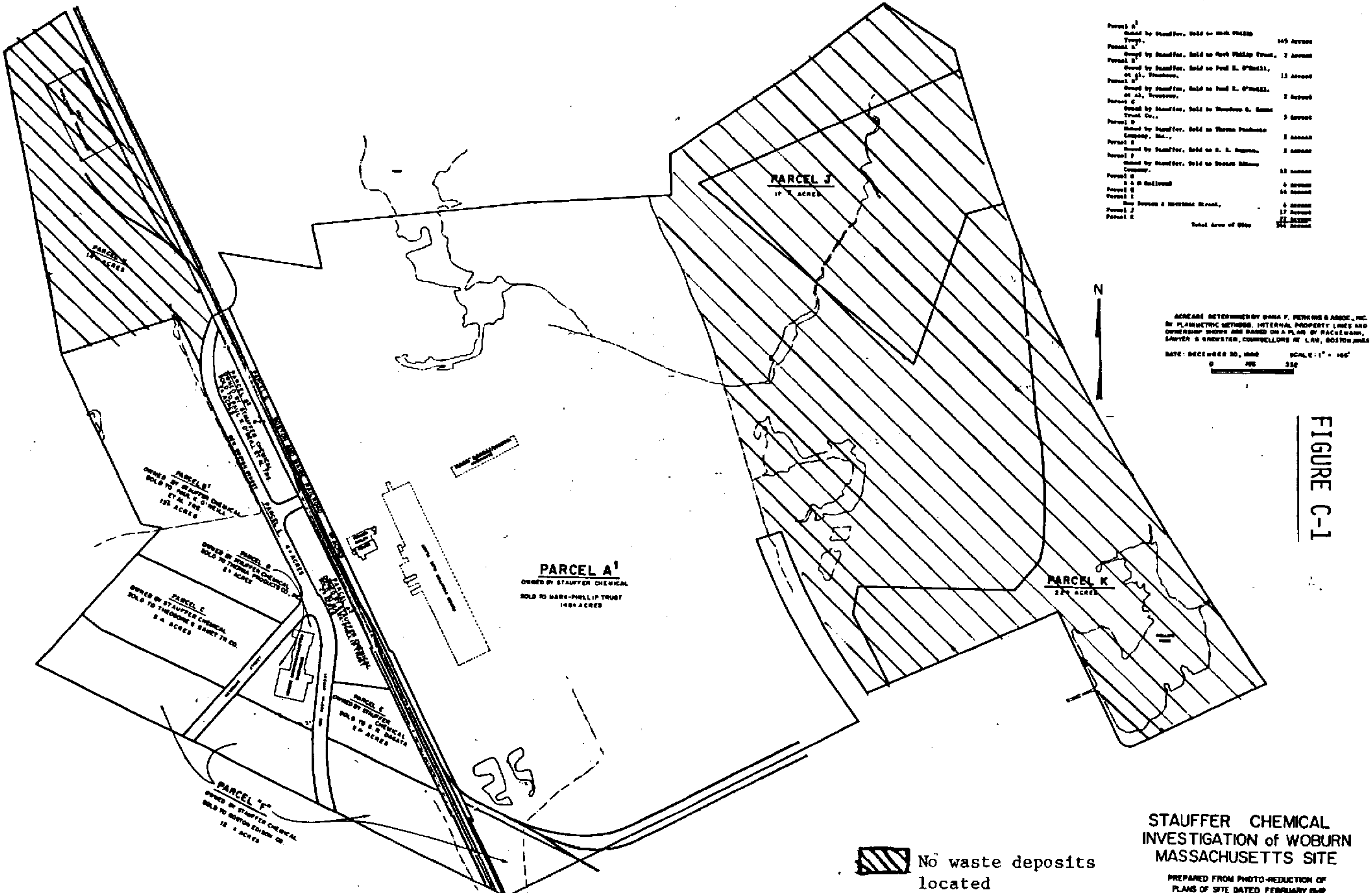
The 120 acres east of Commerce Way contained no waste deposits - see shaded area Figure C-1 attached.

Hide Deposits

The hide deposits are piled in three (3) separate relocated areas -- West Pile, East Pile and South Pile -- and one large undisturbed burial area East Central (Figure D).

The hide deposits were defined as follows:

- East Pile is about 3.8 acres with a volume estimated at 125,000 yd^3.
- The West Pile is about 4.1 acres with a volume estimated at 50,000 yd^3.
- The East Central Buried Hide area is about 10.8 acres with a volume estimated at 142,000 yd^3.



No waste deposits located

STAUFFER CHEMICAL
INVESTIGATION of WOBURN
MASSACHUSETTS SITE

PREPARED FROM PHOTO-REDUCTION OF
PLANS OF SITE DATED FEBRUARY 1982
BY- CAMP, DRESSER and McKEE

FIGURE C-1

HIDE DEPOSITS

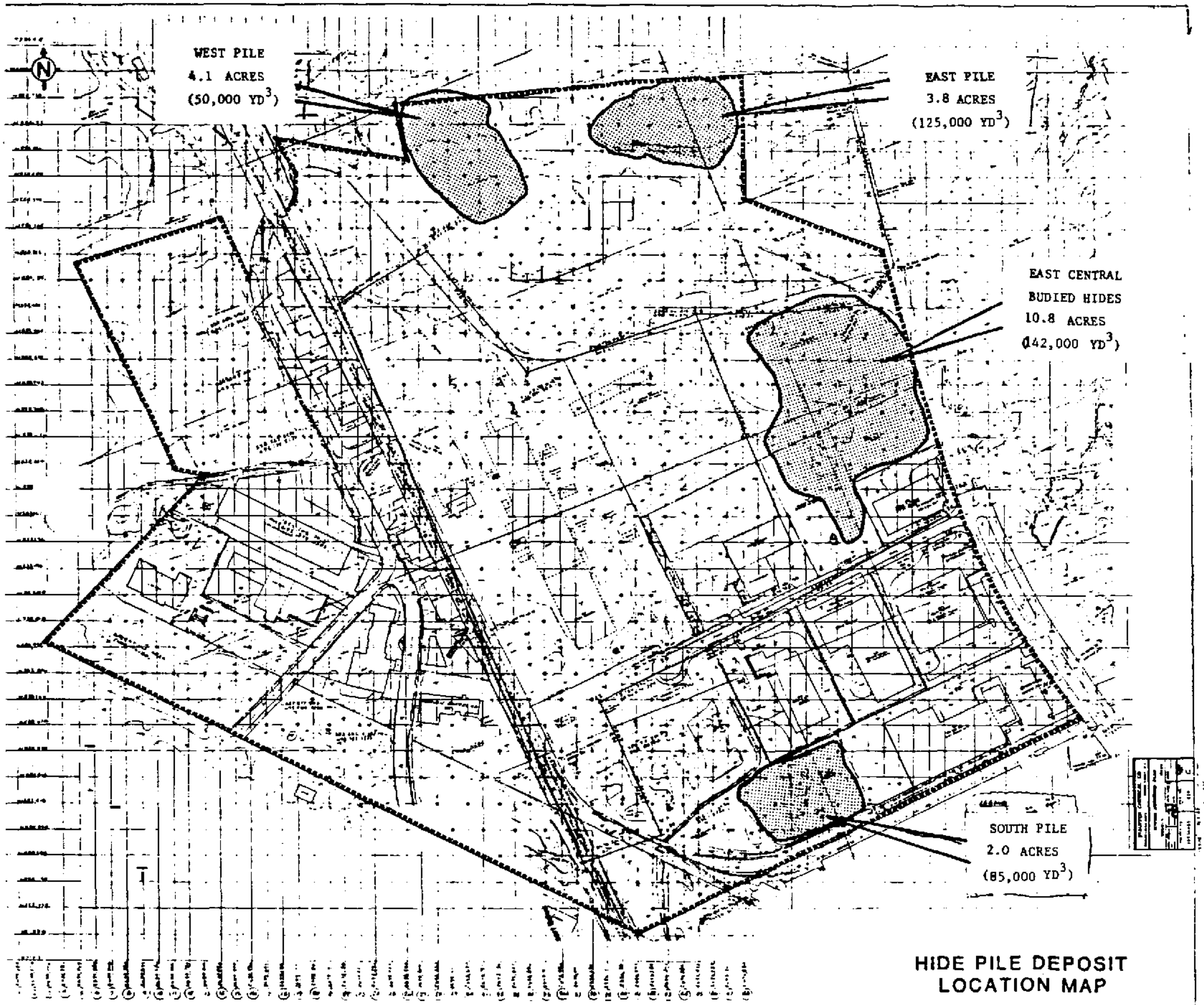


FIGURE D

- The South Hide Pile is 2.0 acres with a volume estimated at 85,000 yd^3.

The piles were created during site development and are commingled with heavy metal wastes of arsenic and lead. The piles are up to forty feet above grade. The piles are unstable and pieces occassionally fall off the sides. The West and East Piles are located under high voltage power lines in the Boston/Edison Right-of-Way and in a wetland area.

The buried East Central hide area has not been disturbed by developers. The waste hides contained untanned and chromium tanned hides.

The East and West hide piles are anaerobically degrading and generating combustible odorous gases in measureable quantities although the West pile generates an order of magnitude less than the East pile. The South pile and buried hides do not appear to be generating measureable gas flows.

Heavy Metals

Heavy metal deposits and soil contamination is widespread on the 90 acres west of Commerce Way. Figure E on the following page shows the 53 acres contaminated with 100 ppm or greater or arsenic, lead and/or chromium. The waste deposits are solids remaining from abandoned settling ponds, i.e., the arsenic and chromium lagoon and deposited as fill for low spots on the property. The heavy metals most frequently and abundantly found on the site are chromium, arsenic, zinc, copper and lead.

>100 PPM CR, PB OR AS IN SOIL

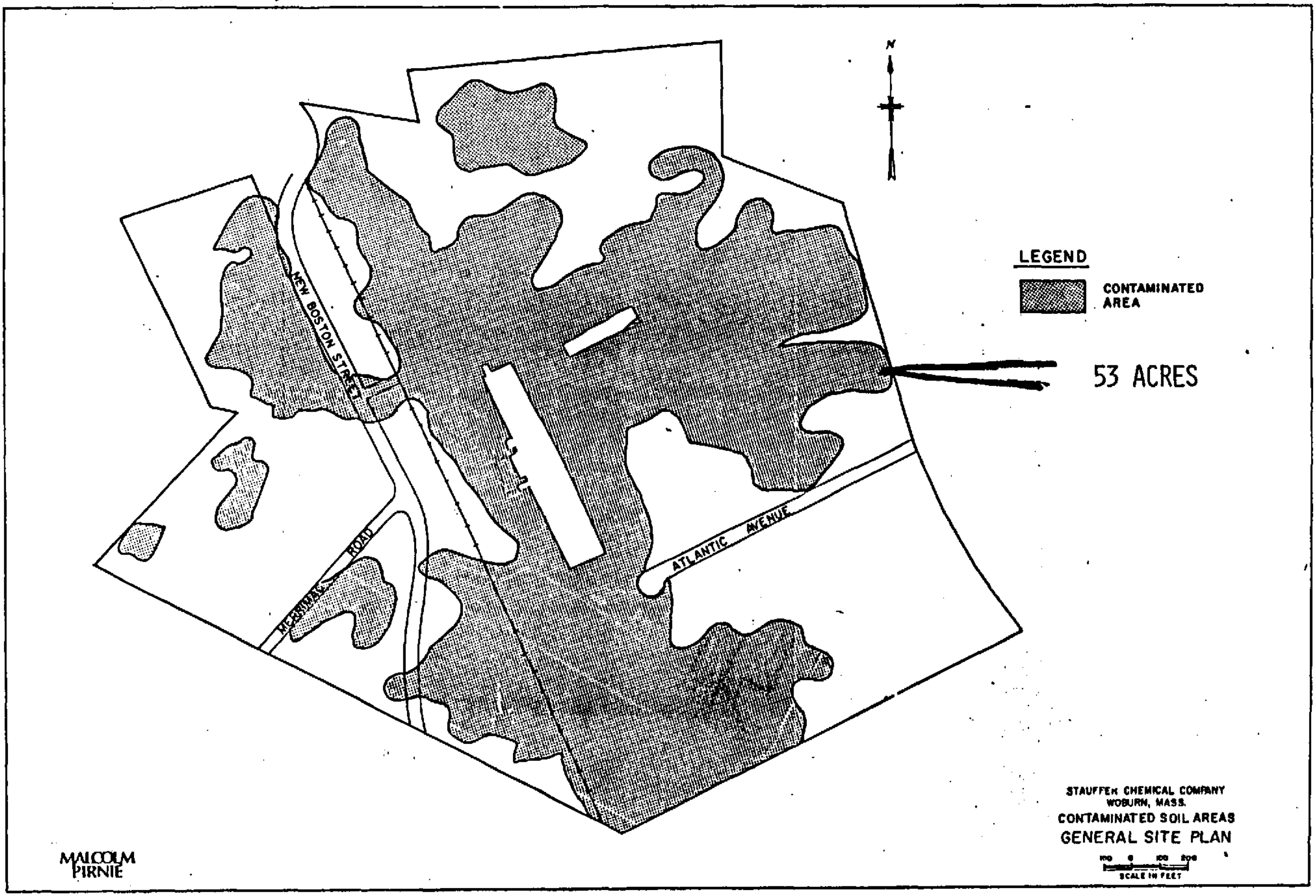


FIGURE E

SHADED AREAS >300 PPM AS, >600 PPM PB, >1,000 PPM CR

IN TOP 2 FEET

43 ACRES

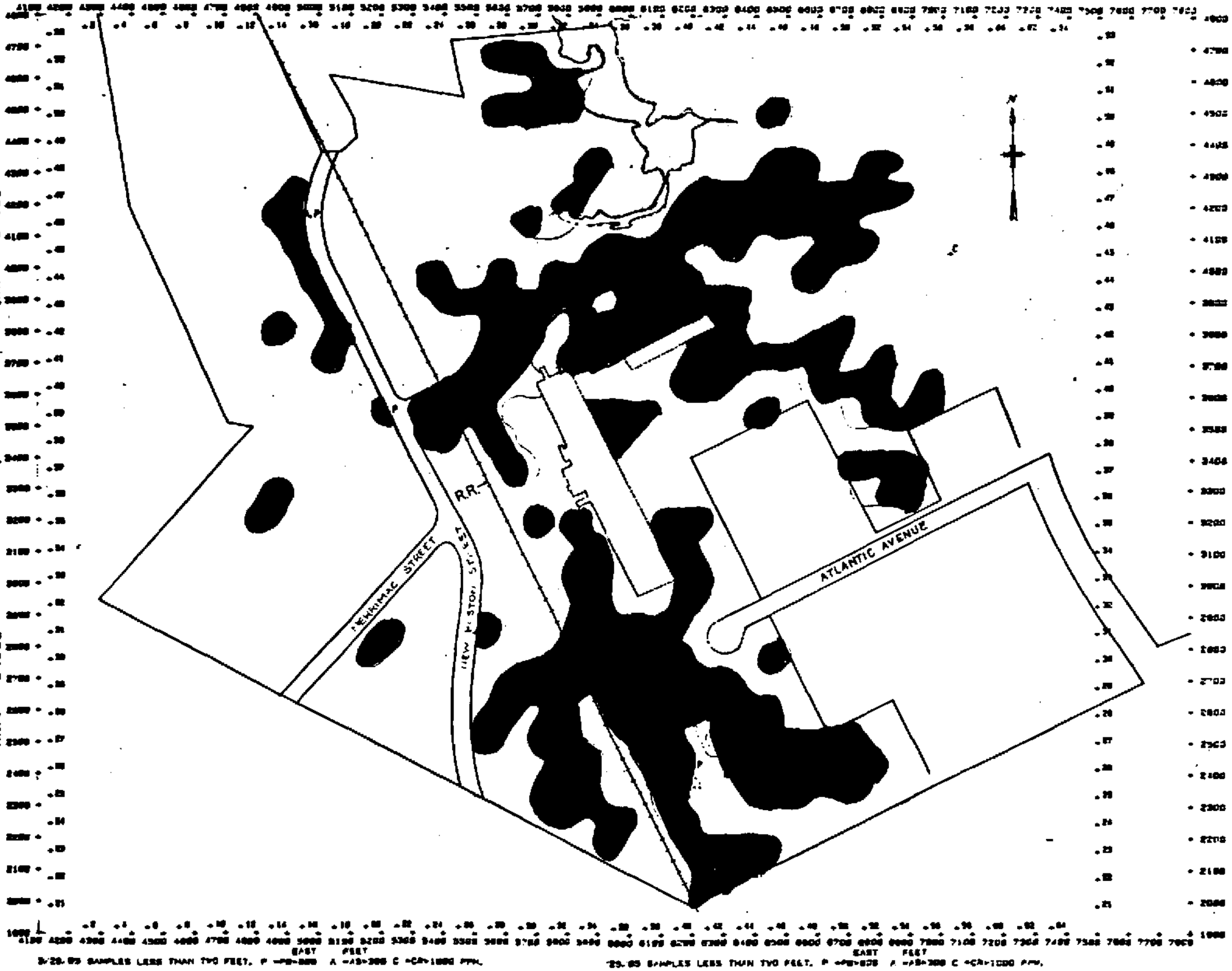


FIGURE F

WOBURN MASSACHUSETTS

PHASE II WOBURN INVESTIGATION
CONCENTRATIONS GREATER THAN
300 ppm As, 600 ppm Pb OR 1,000 ppm Cr

Figure F

In addition, the heavy metal waste deposits and contaminated soil were found over a large area of the site at the surface. Waste deposits and elevated levels of soil were found at surface. Figure F shows 43 acres containing As, Pb and Cr with greater than 300 ppm As, 600 ppm Pb and 1,000 ppm Cr in the top two feet of soil. These levels are above the calculated safe levels for direct contact based upon a health risk assessment of potential acute and chronic effects for applicable routes of exposures (Appendix F). Some areas at the surface show fine powdery material. However, industrial hygiene monitoring and surface water sampling showed no evidence of significant wind blown contamination or stormwater runoff migration (Figure G). In areas near the arsenic pit (11.0 acres) and chromium lagoon (9.5 acres) vegetation distress is evident.

The average depth of the heavy metal deposits was 3 to 4 feet with some deposits extending 8 to 10 feet deep. About 10 - 15% of the deposits are in direct contact with groundwater and most of the remaining deposits are only a few feet above the high water table. However, the buried wastes are densely compacted and the heavy metals highly immobile as evidenced by the groundwater monitoring and RCRA extract test results. The results are detailed in the Remedial Investigation Report, Appendix I, Table 1.1 and 6.4.

The heavy metal wastes are located adjacent to existing building, railroad tracks and road. Water and sewer lines are buried in contaminated areas.

2. ENVIRONMENTAL IMPACT ASSESSMENT

The Remedial Investigation Report assessed environmental impacts, defined odor sources and waste deposits. The report was the culmination of over 2 years of field work. The investigation included resistivity and conductivity surveys over the entire 244 acres, over 950 soil borings, over 100 temporary and permanent groundwater monitoring wells, 53 stream samples, an organic vapor detection survey, 350 gas emission probes, 25 bore hole air samples, an Arthur D. Little (ADL) Odor survey, and a microbiological assessment. The air, water and soil samples were analyzed for the priority pollutants. Additionally, air samples were analyzed for odor causing compounds.

The following summarizes the findings that form the basis for the selection of the remedial actions:

A. Groundwater

Table I (attached) summarizes the groundwater findings in samples where substances were detected. The majority of the samples did not contain detectable levels of chromium, arsenic and lead. Benzene, toluene and bis (2-ethylhexyl) phathalate contamination account for most of the organic chemical contaminants shown on the table.

- Levels of arsenic (100 - 420 ppb) and lead (120 ppb) above the drinking water standard (DWS) were detected sporadically, i.e., arsenic was found in only 1 sample and lead in only 3 out of 16 collected onsite and immediately downgradient above Drinking Water Standards (DWS). These findings do not indicate significant contribution of leachate from waste deposits or a plume of contamination.

- Hexavalent chromium (Cr^{+6}) was not detected in any groundwater samples and total chromium (Cr) was detected in only 3 out of 39 samples.

- Zinc was found in onsite and downgradient wells above secondary drinking water standards (5,000 ppm).

- Localized high ppm levels (32 ppm) of benzene and toluene were found onsite. At wells immediately downgradient of the site boundary, 747 ppb benzene and 177 ppb toluene were found, but no benzene or toluene was found at wells further downgradient. No potable supply wells are operating downgradient of the site within about 1.25 miles. However, the groundwater from the site flows towards Woburn municipal drinking water wells G & H (which are currently not operating) and could eventually impact these wells if left uncontrolled.

B. Surface Water

Table II (attached) summarizes the surface water quality results. No significant contribution of contaminants from waste deposits is evident. The Drinking Water Standards are listed at the bottom left of the Table.

Generally, heavy metals were below drinking water standards and organics were higher upstream than downstream. Earlier EPA, DEQE, and MDC investigations generally supported these findings. However, several samples of surface water collected during earlier investigations showed elevated levels of heavy metals. These samples were not filtered however, and contamination by natural soil particles is suspected as the cause of these findings. The EPA Office of Drinking Methodology for Sampling and Analysis includes filtering.

In a few instances, surface stream sediment samples showed elevated levels of heavy metals onsite, but downstream samples confirmed that the contaminants were not being transported offsite.

C. Air Emissions/Odor

Table III summarizes the results of the odor and volatile emission investigations. The potential sources of odor and gas emission were identified as the East Hide Pile, West Hide Pile, East Central Buried Hides and the South Hide Pile.

- The East Hide Pile was identified by both Arthur D. Little's (ADL) Odor Panel and bore hole gas sampling to be the predominant odor source with gas generation rates measured in bore holes at 2 to 5 cfm and hydrogen sulfide (H_2S) levels up to 47,000 ppm.

- ADL determined that H_2S was the predominant odor causing substance although mercaptans were found in lower levels.

- Volatile organic chemicals were not detected (1 ppm detection limit) above bore holes and only low ppm (10 ppm) levels of ben-

Table 1 Summary of Monitor Well Analysis

Site Locations	Samples Collected Date	#	As #	As Range	Cr #	Cr Range	Cu #	Cu Range	Hg #	Hg Range	Pb #	Pb Range	Zn #	Zn Range	Others #	Others Range	Prior.Poll #	Prior.Poll Range	NonP.P.Org. #	NonP.P.Org. Range
			Heavy Metals - PPB														**Organics - PPB**			
Upgradient OW-1,1A,2,3,4	9/82	5											4	20-100	3	Cd 5-7	4	14-110		
															1	Ni 62				
	8/83	5											4	26-55	3	Be 6-8	5	48-195	4	60-432
Lateral to Site OW 5,6,8,15	9/82	3	1	200									3	41-110	3	Cd 5-6	3	19-69	2	19-236
	8/83	4	1	2									4	18-50	1	Be 8	4	108-887	1	188
On Site or Immediately Down Gradient Of Site															1	Ba 250				
OW 9,10,11,12,13, 14,16,17,18,18A	9/82	6	1	420	1	54	4	25-1000			1	74	6	33-58	3	Cd 5-28	3	15-86	4	83-2746
															1	Ni 32				
	8/83	10	7	2-26	2	100-120*	5	20-840			2	70-120	5	58-5700	7	Be 5-9	9	49-3004	8	81-6632
															1	Ag-10				
															2	Ba 200-230		32ppm+		2ppm+
															2	Ni 60-80				
																Sb 16				
Further Down Gradient Of Site	9/82	1					1	23			1	120	1	51		Cd 5	1	14	1	54
OW 7,19,19A, 20,20A	8/83	1	1	18									1	36			1	36		
	1/84	4	4	7-106									4	20-47000					1	207
Total Samples		39	15		3		10				4		32				30		21	

* Hexavalent Cr N.D.

\+ VOC Sampling and analysis

M. L. Beers

7/30/84

TABLE II

Summary of Surface Water Analysis

Site Sampling Locations	Samples Collector	No	Heavy Metals - PPB														Organics - PPB				
			As		Cr		Cu		Hg		Pb		Zn		Others		No.	Total		P. Poll.	
			*	Range	*	Range	*	Range	*	Range	*	Range	*	Range	*	Range	Samp.	*	Range	*	Range
Upstream (SW-1,8)	SCC 8/82	2									1	100					2	2	202-1199	2	145-475
	SCC 3/83	2									1	66	2	61-66	2	Ba-107-108	2	2	99-646	2	58-362
	Others 1/79-12/81	1											1	30	1	Ba-30	2		NA	2	161-881
On-site (SW-4,6,12,15)	SCC 8/82	3									1	100	2	21-289	2	Be-8 Ni-58-62 Ba-160	3	3	212-402	3	144-262
	SCC 3/83	4															4	4	78-646	3	13-362
	Others	23	17	2-200	4	5-40	6	10-50	8	0.2-3	2	5-8	21	12-470	16	Se-2 Ba-30-180	6		NA	6	8-78
Downstream (SW-5,7,16a)	SCC 8/82	3											2	84-600	2	Ni-52 Be-8	3	3	184-568	3	167-368
	SCC 3/83	3													1	Ba-158	3	3	43-880	2	16-171
Downstream of Industri-plex 128 (SW-19)	SCC 8/82	1									1		1	138			1			1	130
	SCC 3/83	1											1	121			1	1	520	1	431
	Others	10	5	1-27			4	20-50	2	0.2-0.6	2	14-160	2	130-850	4	Ba-40-110	2		NA		
Total Samples		52	22		4		10		10		8		32		28		28	18		25	

(*) Samples which contained detectable concentrations. Detection levels for Stauffer analysis was 1 PPB-Hg; 20 PPB-As,Cu,Zn; 50 PPB-Cr,Pb and 10-25 PPB for most organics.

Drinking Water Std.

- As - 50 PPB (max)
- Cr - 50 PPB hexavalent chromium (max)
- Cu - 1000 PPB
- Hg - 2 PPB (max)
- Pb - 50 PPB (max)
- Zn - 5000 PPB

zene and toluene were detected in air collected 20 feet deep in the bore holes.

- The West Hide Pile is also a potential source of odor since H_2S was found in bore holes. However, the measured gas emission rate in bore holes is low (0.5 cfm), the ADL odor intensity score was low, and only 55 ppm H_2S was found in the bore hole where the gas flow was measured.

- The ADL odor study concluded that the East Central buried hides are not a significant source of odors. No gas generation was measured in this area. However, ADL identified localized odors in places where buried hides were exposed.

- Industrial hygiene total dust and particulate monitoring data showed no levels of chromium (Cr), arsenic (As) or lead (Pb) in excess of the approved OSHA standards.

- Arsine was not detected in 23 of 27 samples of air 20 feet deep in bore holes. In 4 samples, arsine was found at the limit of detection (.3 ppb), well below OSHA's standard for this material. Also, at these minute detection levels, a particle containing arsenic might cause a false detection of arsine.

- Dr. Stephen Edberg, a Yale University microbiologist, surveyed the site and collected and analyzed samples and determined

TABLE III

AIR EMISSION/ODOR EVALUATION

	RANGE OF PHASE II BORE HOLE MEASUREMENTS			ESTIMATED EMISSIONS FROM ENTIRE AREA		ADL ODOR INTENSITY RATINGS	SCC EST. OFFSITE ODOR POTENTIAL
	CFM	H_2S	VOC (ppm)	CFM	H_2S (ppm)		
EAST PILE (15)	.02-1.25	.6-2%	ND-13.5	2-5	2-5%	17000	HIGH
WEST PILE (3)	0-.65	50-700	7-5.5	.5	55	40	LOW
EAST CENTRAL (6)	--	ND-.2%	ND-20	--	--	1600	LOW
SOUTH CENTRAL (1)	--	5000	3.9	--	--	1300	LOW

DRAFT

that no hazard of disease bearing microbes existed at the Woburn site (Appendix J).

The odors, e.g., H_2S and mercaptans and combustible gases (CH_4) are believed to be generated by the anaerobic bacterial decomposition of waste hide materials. Based upon field observation and measurements, the odor incidents are believed to be the results of sudden releases of accumulated gases caused by:

- pile disturbances from excavation, drilling, or collapsing of side slopes.
- water intrusion displacing gases.
- rapid drop in barometric pressures.

3. ENDANGERMENT ASSESSMENT SUMMARY

In order to carry out the endangerment assessment, specific potential receptors were identified. The hydrogeologic consultants, Roux Associates, identified the potential groundwater receptors as the closed Woburn municipal wells (G & H). The potential for concentration of Industri-Plex wastes reaching wells G & H was calculated assuming the groundwater would reach these points using a dispersion formula generally used for this purpose (Appendix A). Stauffer's engineers estimated potential ambient air levels of odorous compounds and volatile organics found in bore hole air using the Texas Episodic Model (Appendix G). The potential exposures to contaminated soil and waste deposits were estimated by Stauffer's certified industrial hygienists for each of the following routes of exposure: ingestion, dermal contact and airborne particulates (Appendix G).

For each hazardous substance of concern, a Limiting Effect Dose (LED) was calculated based upon a careful review of the toxicologic literature describing the acute and chronic effects of each substance in animal and man. The LED represents an estimated safe dose to prevent acute and/or chronic adverse health effects.

Using the potential exposure estimates for each hazardous substance, conservative estimates of potential doses a child and adult might receive were calculated. These doses were then compared to the LED and risks were reported as margins of safety - multiples below the LED (safe dose).

Based upon comments to earlier drafts made by the EPA Office of Drinking Water and the Woburn Citizens Advisory Committee, supplements were made to the September, 1984 Endangerment Assessment for benzene, toluene, acute toxicity and dermal exposure to surface water (Appendix G).

A. Chemicals of Concern

Based upon the frequency of detection onsite and the concentration in each pathway of exposure measured during the site investigation, the following chemicals were included in the risk assessment:

Groundwater

Benzene	Cyanide (CN)
Toluene	Zinc (Zn)
Arsenic (As)	Total Phenols
Lead (Pb)	

Surface Water

Bis (2 ethylhexyl) phthalate (DEHP)	Nickel (Ni)
Zinc	Tetrahydrofuran

Volatile Materials

Hydrogen Sulfide (H_2S)	Benzene
Mercaptans	Toluene

Soil Contaminants

Arsenic (As)	Chromium (Cr)
Lead (Pb)	

B. Groundwater

The potential receptors were identified as the closed Woburn G & H municipal supply wells about 1 1/4 miles downgradient of the site. These wells are finished 88 feet deep in the buried Aberjona Valley and would intercept groundwater from the Woburn site. (Appendix A).

Heavy Metals/Inorganics: The only factor that was considered in estimating the concentrations of inorganics (arsenic, lead, zinc and cyanide) that could eventually reach Wells G & H was dispersion. Dispersion is the process of dilution in the aquifer. Ion exchange factors which consider adsorption of metals on soil were not used because they could only be qualitatively assessed.

Organics: Organic chemical concentrations in groundwater can be reduced through three factors - retardation, dispersion, and biodegradation. Biodegradation at this time can only be qualitatively assessed and was not used in estimating the potential exposures. Retardation is the process of adsorption/absorption of organics on aquifer soils and estimates travel time of contaminates in the aquifer. The retardation factor is quantifiable for organics by using the octanol water partition coefficient for each organic. The calculation considers the aquifer soil bulk density, organic carbon content of aquifer soil and aquifer porosity.

Dispersion is calculated using the same formula used for inorganics (i.e., dilution).

The rate of aquifer flow was estimated by a specific capacity test to be 1 foot/day. The volume of the contaminated groundwater plume for each contaminant was estimated based upon groundwater monitoring data. To be conservative, the maximum concentrations found for each contaminant were used in the dispersion formula calculation. Using these data, expected contamination at G & H wells, assuming that the contaminants currently on-site migrated to these wells, are as follows:

Parts Per Billion (ppb)

Arsenic	7-13	Benzene	5-10
Lead	2.5	Toluene	35
Zinc	1800	DEHP	0.1
Cyanide	0.3	Phenols	140

The estimated exposures show that levels of heavy metals will be below the drinking water standards of 50 ppb for As and Pb and 5,000 ppm Zn should onsite contaminants ever reach the closed G & H wells. Phenols and toluene are also well below the human health protection criteria of 3,500 ppb and 14,300 ppb, respectively.

Only benzene and arsenic are considered animal or potential human carcinogens and thus were subject to a more rigorous risk assessment. To do this, the limiting effect chronic dose for benzene was calculated using EPA's Carcinogen Assessment Group multistage linearized animal to man extrapolation model. This model uses an acceptable cancer risk of 1 additional case in 100,000 (an acceptable risk as recommended by the National Drinking Water Advisory Committee). The estimated benzene concentration that would produce that risk level varies from 6.7 ppb (most conservative) to 30 ppb (most likely). At Woburn Wells G & H, the estimated exposure is 5 ppb but could be as high as 10 ppb for short periods of time when plume areas of highest concentration reached the receptor. Since this estimated concentration may at times exceed the most conservative safe exposure level (6.7 ppb), clean up of benzene in the groundwater is required.

The drinking water standard for arsenic (As) is 50 ppb, a level found by the independent National Research Council to provide an adequate margin of safety. Dispersion models indicate that the estimated arsenic concentration, assuming the contaminants would reach G & H wells, is 7 ppb and possibly up to 13 ppb, both well below the limit.

Based upon the calculated doses and the estimated most likely limiting effect doses, adequate margins of safety exists for all other contaminants in groundwater.

C. Volatile Emissions/Odors

Offsite ambient air levels of hydrogen sulfide, benzene, mercaptan and toluene were calculated (Appendix C) based upon the worst case total pile emission rate of 80 cfm with the highest concentration of H_2S (5%), benzene (11 ppm), mercaptan (475 ppm) and toluene (4 ppm) found in bore hole sampling and analysis. Estimated wind speeds and atmospheric stability classes defined during the ADL 1981 odor survey were used in Texas Episodic Model Version 8 (TEM8). Ground level concentrations at a distance of 700 meters (nearest residences) from the site were predicted as follows:

	Parts Per Billion (ppb)
H_2S	187
Mercaptans	5
Benzene	0.004
Toluene	0.05

Limiting effect doses were calculated based upon a thorough review of the acute and chronic toxicology data and the above estimate were adjusted to approximate large population exposures. For instance, benzene was conservatively adjusted to .022 ppb for estimating the safe dose exposures. Margins of safety calculated for offiste airborne contaminants compared to the limiting effect doses for these compounds were:

	Margin of Safety	
	Acute	Chronic
Benzene	750,000	14
Toluene	640,000	72,000
H_2S	7	1.8
Mercaptan	880	120

While the margins of safety for protection of health are adequate, the H_2S levels of 187 ppb, 700 meters downwind are above the estimated field odor perception level of 70 ppb. (Appendix D). Thus, positive odor control measures will be required.

D. Soil Contaminants/Direct Contact With Heavy Metals

Estimates of potential exposures to contaminated soil via dermal contact, ingestion and breathing dust are presented in the Risk Assessment section along with the calculation of risk. (Appendix G).

Exposure to waste deposits and contaminated soil can occur from children playing on the property, dust migration offsite created during construction and construction worker exposure due to dust and dermal contact. An endangerment assessment (Appendix G) was conducted assuming that a child played on the site a total of 12 days/year, ingested 5 gm/day of soil (highly unlikely), and dermally absorbed some. Worker exposure and offsite exposures assumed conservative dust conditions of 10 mg/m^3 (visibly dusty). The "worst case" average levels of contaminants in the soil (i.e., 620 ug/g lead, 130 ug/g arsenic and 850 ug/g chromium) were used in calculated potential doses. The safety margins for acute and chronic effects calculated for various potential exposures are:

	Acute	Chronic
Offsite (from construction activity)	3,500	26
*Onsite	16	3.6
Construction Activity (Worker Exposure)	300	Not Applicable

*Combines ingestion, absorption and breathing during period of no construction.

This analysis determined that exposures to surface contamination would result in no adverse effect based on the average "worst case" concentrations of heavy metals in site soil.

E. Drinking Surface Water

Estimates of potential exposures to surface water were made based on a highly speculative senario of a child or adult actually drinking surface water from the Woburn site. Details are in the risk assessment section. To do this, the average concentrations were determined for the following substances found onsite in wastes at significant concentrations: 171 ppb bis (2-ethylhexyl) phthalate; 59 ppb nickel; 90 ppb zinc; 19 ppb tetrahydrofuran.

Potential risks were calculated using highly conservative assumptions. There are no heavy metals above drinking water standards. None of the four substances found in significant concentrations are animal or human carcinogens. Limiting effect dose calculations were made for these substances assuming that 1 liter of surface water was consumed 12 days/year. On this basis, the safety margins shown below were calculated.

	Safety Margin	
	Acute	Chronic
DEHP	18,000	1,800
Zinc	560	3,300
Nickel	170	260
Tetrahydrofuran	53,000	160,000

These results demonstrate that the site surface water poses no significant risk to human health.

F. Dermal Contact With Surface Water (Bathing)

Based upon concentrations of contaminants detailed above and using skin absorption rates published by EPA's Office of Drinking Water, a child bathing 1 hour per day, 12 days per year will have a safety margin at least 700 fold lower than the calculated safe doses for these substances.

3. DESCRIPTION OF SITE PROBLEMS

Based upon the Remedial Investigation Report, the environmental impact assessment and endangerment assessment, those site problems requiring attention have been determined to be benzene and toluene contamination in groundwater, emissions of odorous gases from the East Hide Pile, and potential direct contact hazard with exposed waste deposits and soil having elevated levels of chromium, arsenic and lead.

A. Groundwater Contamination with Benzene and Toluene

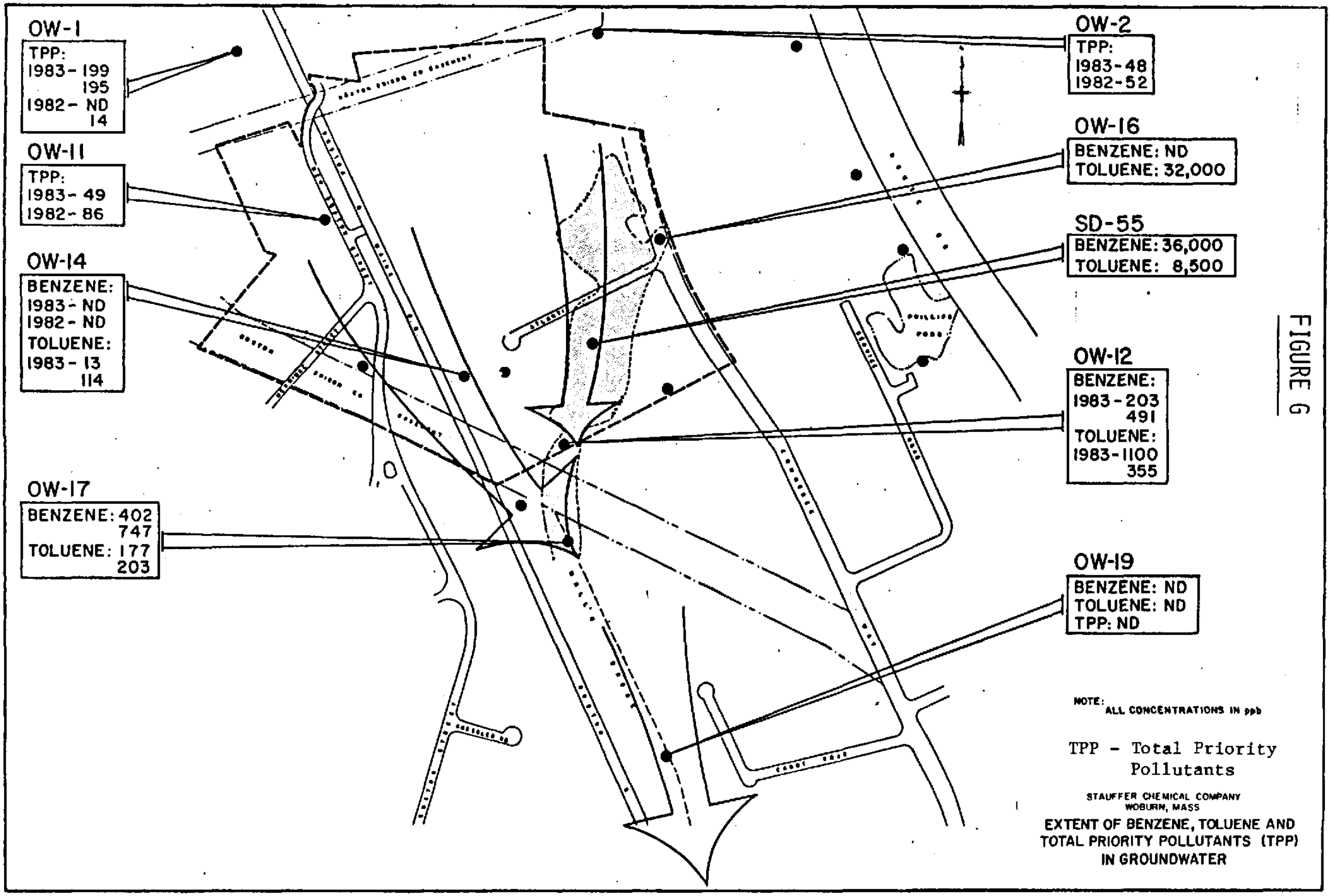
The groundwater monitoring program established benzene at 36 ppm and toluene at 32 ppm at onsite monitoring wells SD55 and OW-16 respectively. The furthest downgradient point at which benzene and toluene were detected is Well OW-17 (747 ppb and 177 ppb respectively). This well is about 300 feet downgradient of groundwater flow from the southern boundary of the site. Figure G attached shows the benzene and toluene plume in the shaded area as well as monitor well results. The estimated extent of the plume is based upon analytical results of 65 temporary monitoring wells. No benzene or toluene has been detected at Well OW-19, located 1/2 mile downgradient of the site in the buried Abejona Valley aquifer between the site and G & H wells. One would expect to find these substances in Well OW-19 had they migrated to this point.

We estimate that if the benzene is left to migrate uncontrolled, in about 20 years it could reach G & H wells at 10 ppb (Appendix A). This would exceed the current EPA-NAS Suggested No Adverse Effect Level (SNARL) for drinking water of 6.7 ppb. While Woburn G & H wells are not now used, EPA plans to clean up the aquifer to permit well use in the future. Thus, remedial action to reduce these contaminants in groundwater is required.

B. Emission of Odorous Gases East Pile

Based upon 350 gas emission probes, 53 bore hole air samples, and the Arthur D. Little (ADL) Odor Panel survey of hide deposit areas, emissions of H_2S from the East Pile was identified as the predominant source of site odors and odor incidents. The investigation found that the East Pile generates up to 2-5 cubic feet per minute (cfm) of gas containing methane, ORGANI

GROUNDWATER



up to 5% hydrogen sulfide (H_2S) and low ppm concentrations of mercaptans.

Odor incidents are believed to be caused by sudden releases of accumulated gases generated by the anearobic decomposition of the hides when the pile sides collapse, water rapidly intrudes and barometric pressure drops sharply. The East Pile stands 40 feet high, covers 3.8 acres and contains 125,000 yd^3 of mixed waste hides and heavy metal contaminated soil. The pile is located in the wetlands on the northern boundary directly under power transmission lines of Boston/Edison. We estimated that the worst case emission of odors if the pile were left uncontrolled would reach 187 ppb H_2S at the property line which is well above the estimated East Pile odor threshold (20 - 150 ppb) for the sensitive ADL odor panel.

C. Elevated Levels Arsenic, Lead and Chromium in Soil

The Remedial Investigation found elevated levels of chromium (Cr), arsenic (As), and lead (Pb) in the top two feet of surface soil and subsurface to depths of 10 feet (Figure E). The endangerment and environmental impact assessments determined that under current site conditions, these wastes do not adversely impact surface water quality and do not present an imminent and substantial endangerment of human health due to direct contact exposure. In addition, groundwater monitoring results (Figure H) and RCRA extract test results show an extremely low potential for leaching of these metals to groundwater. (Remedial Investigation Report, Appendix I, Table 1.1 & 6.4).

HEAVY ME LS
GROUNDWATER

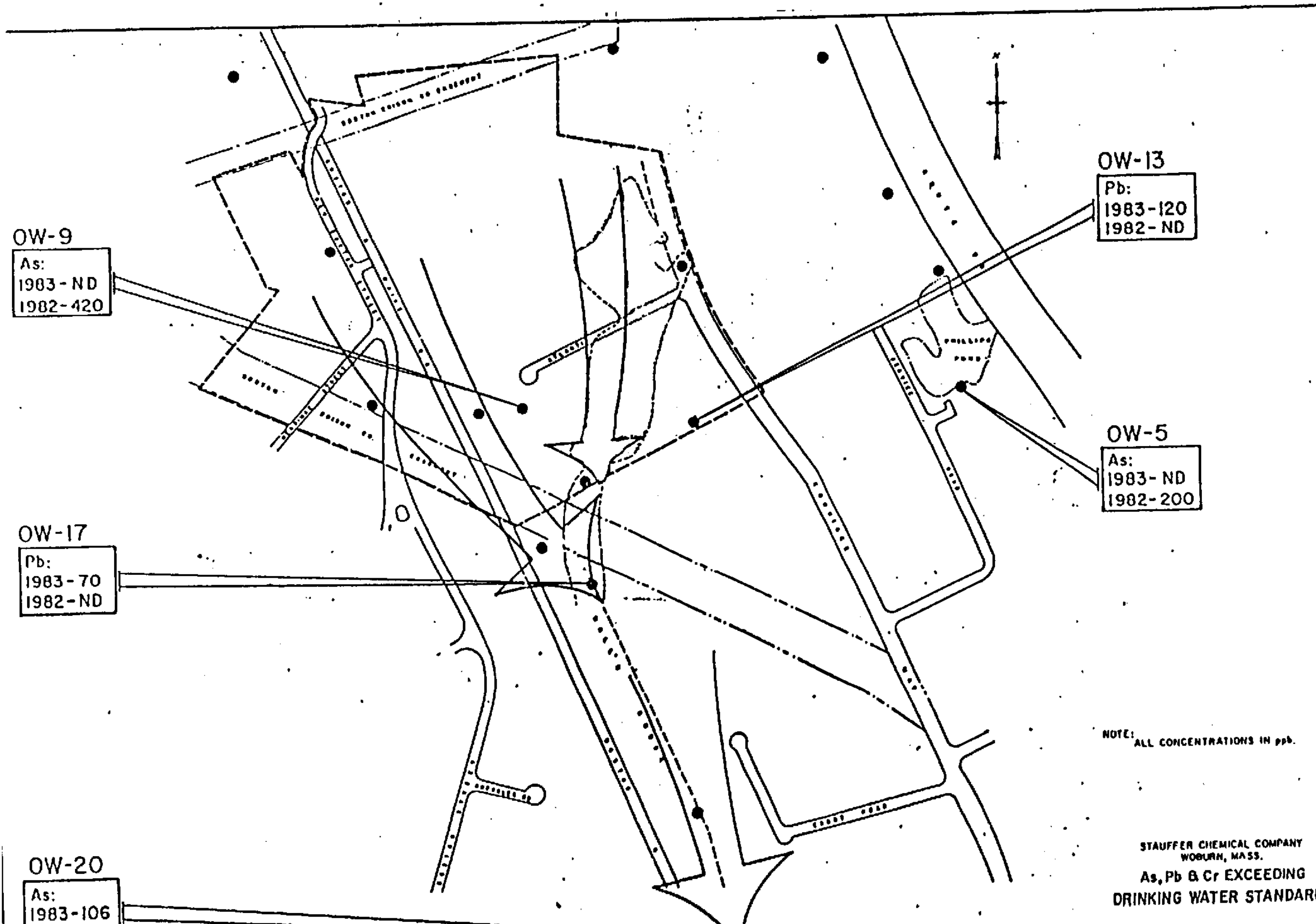


FIGURE H

The soil contaminants include 53 acres of chromium, arsenic and lead at greater than 100 ppm and 15 acres of hides with elevated levels of chromium in the West, East Central and South Piles. The East Pile is not included since remedial action for odor control will address the potential direct contact hazards, potential erosion of contaminants to surface water and the potential for leaching to groundwater or surface water. The estimated safe levels for direct contact exposure to arsenic, lead or chromium are 1,000 ppm, 600 ppm, and 1,000 ppm, respectively (Appendix F). Those areas with As greater than 300 ppm pose a threat to the environment since they will not support vegetation which is needed to reduce the potential for contaminant erosion to surface water. (Appendix E).

Municipal water and sewer lines are buried in contaminated soil and repairs or replacement might involve contaminated soil disposal and potential direct contact hazards. These lines are buried 4 feet and 8 feet below grade respectively (Appendix H) throughout the site.

Soil contamination and waste deposits were found to extend across railroad tracks and into developed areas of the site. In addition about 10-15% of the wastes are buried below the high ~~water~~ groundwater level. Buried hide wastes are extremely odorous if excavated as evidenced by odor complaints during earlier site development attempts.

REMEDIAL OBJECTIVES

SECTION IV

1. OVERALL ENVIRONMENTAL OBJECTIVES

The objectives of the remedial action are as follows:

A. Groundwater

- Prevent adverse impacts on downgradient uses
- Prevent significant impact on surface waters

B. Surface Water

- Assure no significant contribution of contaminants from waste deposits
- Assure no detrimental impact on onsite and downstream water uses

C. Soil and Hide Pile Deposits

- Reduce potential for exposure to hazardous levels of contaminants from direct contact
- Minimize restrictions on future development

D. Air

- Assure volatile and soil particulate contaminants do not exceed standards or create offsite or onsite health hazards
- Eliminate nuisance odors attributable to site waste deposits

2. SPECIFIC DIRECTED GOALS OF REMEDIAL ACTION

The extensive remedial investigation and the endangerment and environmental impact assessments have defined the site problems as follows: groundwater contamination with benzene and toluene migrating towards the closed Woburn G & H municipal drinking water wells, emission of odor causing compounds from the East Pile, and soil/waste deposits with elevated levels of arsenic, lead and chromium. Therefore, the specific goals of the remedial actions are as follows:

- prevent levels of benzene and toluene in excess of drinking water SNARL's at G & H wells;
- reduce levels of odor causing compounds emitted by the East Pile so that the ambient air levels remain below the odor threshold.
- eliminate the effects of sudden water intrusions to the East pile, rapid barometric pressure drops and collapsing of pile sides.
- reduce the potential for erosion of chromium (Cr), arsenic (As), and lead (Pb) to surface water;
- reduce the potential for direct contact exposure to levels of arsenic, chromium and lead in soil that might create adverse health effects;

- provide for development of as much of the site as possible for its planned use as an industrial park taking into account cost and potential adverse health and environmental effects;

- reduce the threat of leaching of chromium, arsenic and lead to groundwater, causing levels in excess of drinking water standards at G & H wells;

- assure that surface waters are not adversely impacted by the remedy; and

- assure that ambient air levels are not adversely affected by the remedy.

3. RELEVANT LAWS, REGULATIONS AND STANDARDS

The remedial actions will be evaluated taking into consideration the following relevant rules and standards:

A. Resource Conservation and Recovery Act (RCRA)

RCRA regulations were specifically promulgated to control active hazardous waste treatment, disposal and storage facilities. RCRA rules apply to wastes defined as RCRA hazardous. RCRA hazardous wastes are either listed in the Code of Federal Regulations or meet the RCRA characteristics of ignitability, corrosivity (pH), reactivity, or leachability. The extensive site investigations found no waste deposits of RCRA listed wastes, reactive, ignitable or corrosive deposits. In addition, RCRA EP toxicity tests performed on composite soil and waste deposits show levels of heavy metals 100 times less than the drinking water standards. Consequently, RCRA rules would not apply to heavy metal deposits. However, findings of benzene in groundwater and site history reports of benzene manufacturing could be interpreted to mean a listed RCRA waste was disposed of on the site.

Interim Status: RCRA has developed closure requirements for facilities that were in operation prior to promulgation of RCRA rules and continued operation after RCRA rules were promulgated, but closed prior to receiving a final RCRA permit. These facilities are called interim status facilities.

The Woburn site most closely resembles an interim status facility since wastes were deposited prior to RCRA implementation and closure will occur prior to RCRA permitting. Interim status closure rules require installation and maintenance of a cover material which is less permeable than the underlying soil and a groundwater monitoring program.

Part B Facilities: RCRA facilities that have received final permits (so-called Part B permits) must meet more stringent rules than the closure rules under the interim status requirements. The Part B permit requires covering with less permeable material than underlying soil, groundwater monitoring, maintenance of monitoring program and covers, control of surface water "run on" and "run off", corrective action if groundwater contamination is detected and treating groundwater and gas emission control. The Woburn site is not an active waste disposal facility and it is not appropriate to apply rules for ongoing waste management operations to inactive disposal sites.

B. Clean Water Act (CWA)

The Clean Water Act (CWA) establishes permit requirements, guidelines and standards for discharge of process waste waters to surface streams (effluent guidelines) and standards for pretreatment of discharges to publically owned treatment works (POTW pretreatment standards).

Surface water discharges from any onsite treatment facility will require National Pollution Discharge Elimination (NPDES) Permits. However, the groundwater is not a process waste and no categorical effluent guidelines or standard applies. Pretreatment requirements for discharge to Publicly Owned Treatment Works (POTW's) would be applied by the local authorities. The local POTW rules do not allow discharge of groundwater to the system or introduction of significant levels of benzene even though the discharge would impose little burden on the POTW since the levels of contaminants are low, e.g. toluene and benzene (30 ppm) and heavy metals are below drinking water standards. The organics are biodegradable and will not impact the sewer system or the receiving water adversely.

C. Surface Water Quality Criteria

Massachusetts has developed surface water quality criteria for protection of human health and aquatic life for benzene, toluene, chromium, arsenic, lead and zinc and should be considered in the evaluation of remedial alternatives. The surface waters on the Woburn site are part of the Mystic River Basin and classified as "B" recreation and warm water fishery not a public water supply (Figure N).

D. Wetlands

Some wetlands drainage and rerouting will be needed since waste deposits are located in the wetlands. Approval of the local commission with authority to approve wetlands development will be needed. Some of this work has already been approved as part of the Sheehy property development, adjacent to the northerly border of the Woburn site.

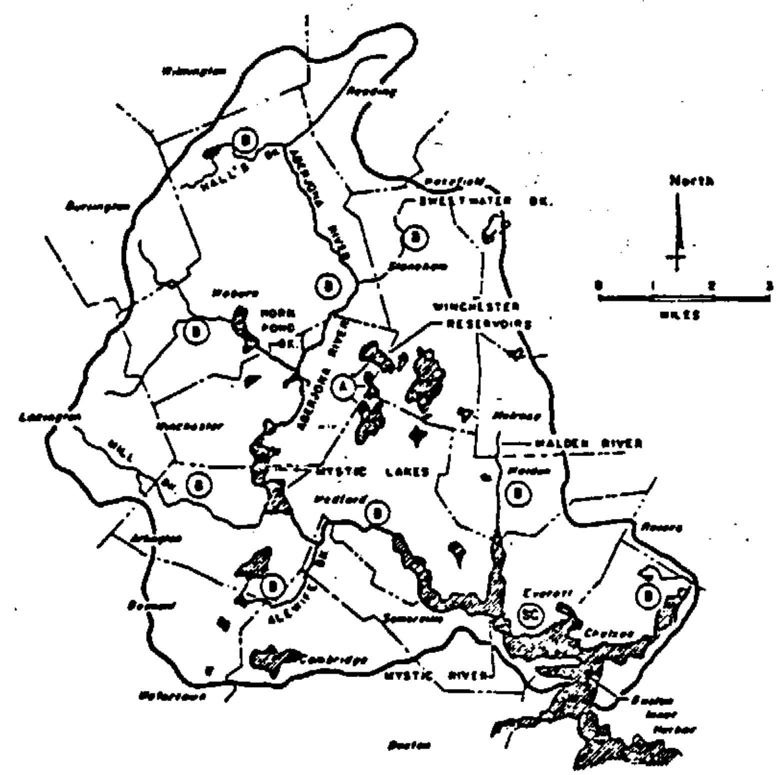
E. Flood Control

Rerouting of surface water will require careful consideration of downsteam flooding potential. Appropriate flood control devices will be installed, based upon engineering assessment and town engineer inputs. The Sheehy property development has already addressed many of these issues and has had a beneficial effect on the Industri-Plex site.

F. Deed Restrictions

Since some property owners will retain land containing contaminated soil and waste deposits, appropriate deed restrictions are needed so that future property development will assure protection of workers and public health during use or development of these properties. Based upon site investigation, these measures need not be too restrictive. They likely will require compliance with RCRA rules for excavation of contaminated soil based upon RCRA extract test and compliance with OSHA exposure limits for total dust, H_2S and explosive gases.

FIGURE N



MYSTIC RIVER BASIN

TABLE 18
MYSTIC RIVER BASIN
DRAINAGE AREA 39

BOUNDARY	MILE POINTS	CLASSIFICATION	DESIGNATED USES	OTHER RESTRICTIONS
Aberjona River				
Source to outlet Mishawum Lake	16.4 - 15.1	B	Warm Water Fishery Recreation (P&S)	Regulation 4.3
Outlet Mishawum Lake to inlet Mystic Lake	15.1 - 9.2	B	Warm Water Fishery Recreation (P&S)	
Upper Mystic Lake	9.2 - 8.1	B	Warm Water Fishery Recreation (P&S)	
Lower Mystic Lake	8.1 - 7.4	B	Warm Water Fishery Recreation (P&S)	
Mystic River				
Outlet Lower Mystic Lake to Amelia Earhart Dam	7.4 - 2.0	B	Warm Water Fishery Recreation (P&S)	
Amelia Earhart Dam to confluence with the Chelsea River	2.0 - 0.0	SC	Marine Fishery Recreation (S)	
Malden River				
Entire Length	3.9 - 0.0	B	Warm Water Fishery Recreation (P&S)	
Alewife Brook				
Entire Length	2.0 - 0.0	B	Warm Water Fishery Recreation (P&S)	
Horn Pond, Woburn	-	B	Warm Water Fishery Recreation (P&S)	Emergency Water Supply
North Reservoir, Middle Reservoir, and South Reservoir in Winchester, Stoneham and Medford	-	A	Public Water Supply	MGL, Ch. 111
Crystal Lake Wakefield and Stoneham	-	A	Public Water Supply	Treated
Other surface waters in the Mystic River Drainage Basin unless otherwise denoted above	-	B	-	Regulation 4.3

G. Safe Drinking Water Act (SDWA)

The SDWA establishes Maximum Contaminant Levels (MCL) for heavy metals and some organics and pesticides in drinking water.

Applicable MCL's for heavy metals detected onsite are:

	SDWA MCL (ppb)
As	50
Pb	50
Zn	5,000
Cr^{+6}	50

The SDWA also regulates the injection of wastes via the Underground Injection Control (UIC) regulations. The UIC rules would apply if reinjection of treated groundwater is needed.

H. Suggested No Adverse Response Levels (SNARL's) For Drinking Water

No MCL's for benzene or toluene have been promulgated. The National Academy of Science recommends a SNARL for drinking water of 6.7 ppb benzene.

I. Endangered Species

No endangered species have been found to inhabit at the Woburn site.

J. Clean Air Act (CAA)

The Clean Air Act (CAA) establishes National Ambient Air Quality Standards (NAAQS) for certain criteria pollutants, including ozone and sulfur oxides. It further mandates state regulatory actions designed to achieve compliance with such standards. Massachusetts has established point source control regulations and has authority to administer other CAA provisions and programs, including permitting under federal New Source

Performance Standards (NSPS), National Emission Standards for Hazardous Air Pollutants (NESHAP) and Prevention of Significant Deterioration (PSD) regulations.

Since remedial action alternatives will consider the collection and venting of hydrogen sulfide, mercaptans, benzene and toluene through a stack, permit provisions and limitations of the Clean Air Act and pertinent Massachusetts regulations may be relevant. The following provisions of Clean Air Act rules were considered:

NAAQS Attainment: The Woburn site is presently an attainment area of the standards for sulfur oxides and ozone. While emissions of hydrocarbons are anticipated, these will be in the parts per billion concentration range at the property line and have no relevance to NAAQS compliance.

PSD: Emissions of regulated pollutants is limited to less than de-minimus levels of hydrogen sulfide and volatile organic compounds, i.e., 50 tons/year and 40 tons/ year respectively.

NESHAP and NSPS: There are no relevent standards under these sections of the CAA which would be applicable to the proposed remedial action plan.

Permits: Massachusetts regulations require a permit for construction and operation of a vent stack. Applications will be filed as necessary.

Nusiance Odor: Massachusetts DEQE rules prohibit the creation of nuisance odors. The policy of the DEQE requires treatment of stack gases to eliminate nuisance odors.

K. National Environmental Protection Act (NEPA)

The Woburn Remedial Investigation and Feasibility Study constitutes and environmental impact statement in compliance with NEPA.

SUMMARY & DISCUSSION OF VIABLE REMEDIAL ALTERNATIVES

SECTION V

This summary decribes those remedial alternatives that were considered in the section entitled "Remedial Alternatives Screening and Ranking" and judged to be most likely to satisfy the remedial objectives at Woburn. The screening and ranking section ruled out a large number of options because of anticipated technical infeasibility, inadequate environmental effectiveness, excessive (order of magnitude) costs, and/or non-compliance with regulatory rules. For instance, intercepting the contaminated groundwater and discharging it to the Metropolitan District Commission (MDC) sewer system provides the greatest environmental protection at the Industri-Plex site with the least cost and fewest operating problems. This approach also has an insignificant impact on the sewer system and receiving water since the discharge would be less than 1% of the total system flow. However, this option was dismissed because the MDC refused to accept the discharge of groundwater.

This section will review each viable alternative in relation to the remedial objectives discussed earlier in this report and the site problems listed below:

- Groundwater contaminated with Benzene and Toluene.
- Emission of Odor Causing Compounds from the East Pile.
- Waste Deposits and Soil Contaminated with Heavy Metals

The discussion will provide a restatement of the problem and objectives, list the viable alternatives with a brief description of each, a recommended action and a basis for selection, a detailed description of the recommended action, an analysis of the recommended action's compliance with regulatory standards and criteria, and an estimate of capital, operating and maintenance (O/M) costs.

1. GROUNDWATER CONTAMINATED WITH BENZENE AND TOLUENE

A. Problem

The remedial investigation reported levels of benzene and toluene about 30 ppm onsite. The plume containing 100 ppb or greater was defined as extending a few hundred feet downgradient of the site boundary (Figure IV following Page 43). Roux Associates calculated (Appendix A) that, if left uncontrolled, benzene would reach the closed Woburn G & H wells in about 20 years at levels up to 10 ppb. This level exceeds the EPA Suggested No Adverse Effort Level (SNARL) for drinking water of 6.7 ppb.

B. Objective

The objective of the remedial action is to prevent benzene from reaching the closed G & H wells in excess of the EPA/NAS SNARL of 6.7 ppb.

C. Viable Remedial Option

The viable remedial options identified by the Malcolm Pirnie ranking are as follows.

	Capital & O/M Costs
- Pump localized high concentrations of benzene, air strip to remove benzene, hydrogen peroxide (H_2O_2) treatment to control odors, recharge to the aquifer upgradient of the source point.	$930,000
- Intercept the groundwater benzene plume at the site boundary, air strip to remove benzene, remove BOD, H_2O_2 odor control, and discharge to the Halls Brook storage area.	$3,650,000
- Pump at the leading edge of the plume, air strip to remove benzene, remove BOD, H_2O_2 odor control, remove zinc and discharge to Halls Brook storage area.	$11,000,000

The cost estimates are detailed in Appendix I. Operating and maintenance (O/M) costs are for 15 years at 6% discount rate.

D. Recommended Action

The recommended action is to pump all the groundwater leaving the site at the site boundary; treat the water to assure compliance with "Surface Water Quality Criteria" for protection of aquatic life and protection of human health for drinking water, and discharge to the Hall's Brook storage area.

This option, based upon Roux Associates calculations, will intercept over 95% of the benzene and the remaining contamination downgradient of the site will disperse in the aquifer to a level not to exceed 2 ppb at G & H wells (Appendix B). This is 3 times lower than the EPA/NAS SNARL for benzene of 6.7 ppb. In addition, the remote threat of migration of chromium, arsenic and lead to G & H wells is eliminated since all the site groundwater is intercepted.

E. Regulatory Compliance

The surface water discharge will comply with "Surface Water Quality Criteria" and human health standards (Table IV attached). The emission of benzene from the air stripper will be about .4 ppb at the property line, well below Massachusetts calculated acceptable level of 100 ppb and average background levels of 4 ppb found in other cities. (Appendix C).

F. Description of Recommended Action

The benzene and toluene plume will be intercepted in the vicinity of monitoring well OW-12 at the site boundary (Figure O) by a series of 5 wells, each 6 inches in diameter which will pump approximately 20 gpm each. Total volume of the system will be 100 gpm. For design purposes, the quality of the pumped groundwater was estimated based on the average quality of water in the wells in the vicinity of the site boundary (Table IV). Heavy metals are generally below drinking water standards and no treatment is needed to discharge to Hall's Brook storage area. Benzene must be air stripped to meet the EPA SNARL for drinking water in the stream. BOD levels (300 ppm) will require treatment to meet typical 15 ppm discharge limits for NPDES permits. Odors were noted during sampling of wells at the site boundary and odor causing mercaptans were found during analysis. Therefore, hydrogen peroxide (H_2O_2) treatment for odors will be provided. A schematic of the treatment system (Figure P) is attached together with the proposed site location (Figure Q). The groundwater treatment system will remove 99.93% of the benzene and toluene currently estimated to be present in the groundwater. The design basis for the system is as follows:

TABLE IV

INTERCEPTION AT SITE BOUNDARY
TREATMENT EFFICIENCIES FOR DISCHARGE TO SURFACE WATER (2)

Element or Compound	Influent Concentration (1) (ppb)	Removal Efficiency	Estimated (4) In-Stream Concentration (ppb)	Water Quality Criteria Documents: Fresh Water Aquatic Life		Human Health (5) Criteria (ppb)
				Acute (ppb)	Chronic (ppb)	
Antimony	5	N/A	-	9,000	1,600	-
Arsenic	10	N/A	3	440	-	50 (5)
Beryllium	7	N/A	2	130	5.3	3.7
Chromium	80	N/A	27	9,900	44	170,000
Copper	10	N/A	3	43	-	1,000
Lead	25	N/A	8	20	-	50
Nickel	67	N/A	22	160	-	13.4
Silver	10	N/A	3	13	-	50
Zinc	104	N/A	33	47	-	5,000 (5)
Benzene	9,300	99.93%	2.2	5,300	-	6.8 (6)
Phenol	260	95%	13	10,200	2,560	3,500
Toluene	10,300	99.93%	2.4	17,500	-	14,300
BOD	300 ppm	95%	15 ppm	-	-	-

Notes:

1. Assumed from average of OW-12, OW-16, OW-17 and SD-55.
2. Treatment System: Biological/Air Stripping.
3. A dash (-) indicates that a level has not yet been determined. N/A indicates that removal is not applicable at the influent concentrations listed to maintain compliance with currently existing regulations.
4. Estimated in-stream concentrations are based on dilution factors of approximately 33 percent for the receiving water low flow of 300,000 gpd and estimated effluent of 150,000 gpd.
5. Human Health Critiera are comprised of either chronic human health concentrations (from Water Quality Critiera Documents) or Safe Drinking Water Act (SDWA) standards. In cases where the SDWA was used, a footnote (5) appears.
6. SNARL (Suggested No Adverse Response Level) for benzene at risk level of 1×10^{-5}.

Total pumping rate:	110 gpm
Water loading rate:	32 gpm/ft^2
Column diameter:	2 feet
Column surface area:	3.14 feet
Air to water ratio:	60 (air): 1 (water)
Required blower capacity:	880 cfm
Total packing height required:	40 feet

Purchase of about one acre of land to house the equipment is provided in the design. A full time operator will be needed for this system and is provided for in the cost estimate.

G. Permits

An NPDES permit from Massachusetts will be needed to discharge to the surface water. Normal procedures would take from 6 months to one year to obtain this permit. A permit for the emission of VOC's from the air stripper is required by Massachusetts DEQE. However, the strippers will emit 950 lbs./year of VOC which is well below the Massachusetts major source cutoff of 10,000 lbs./year.

H. Cost

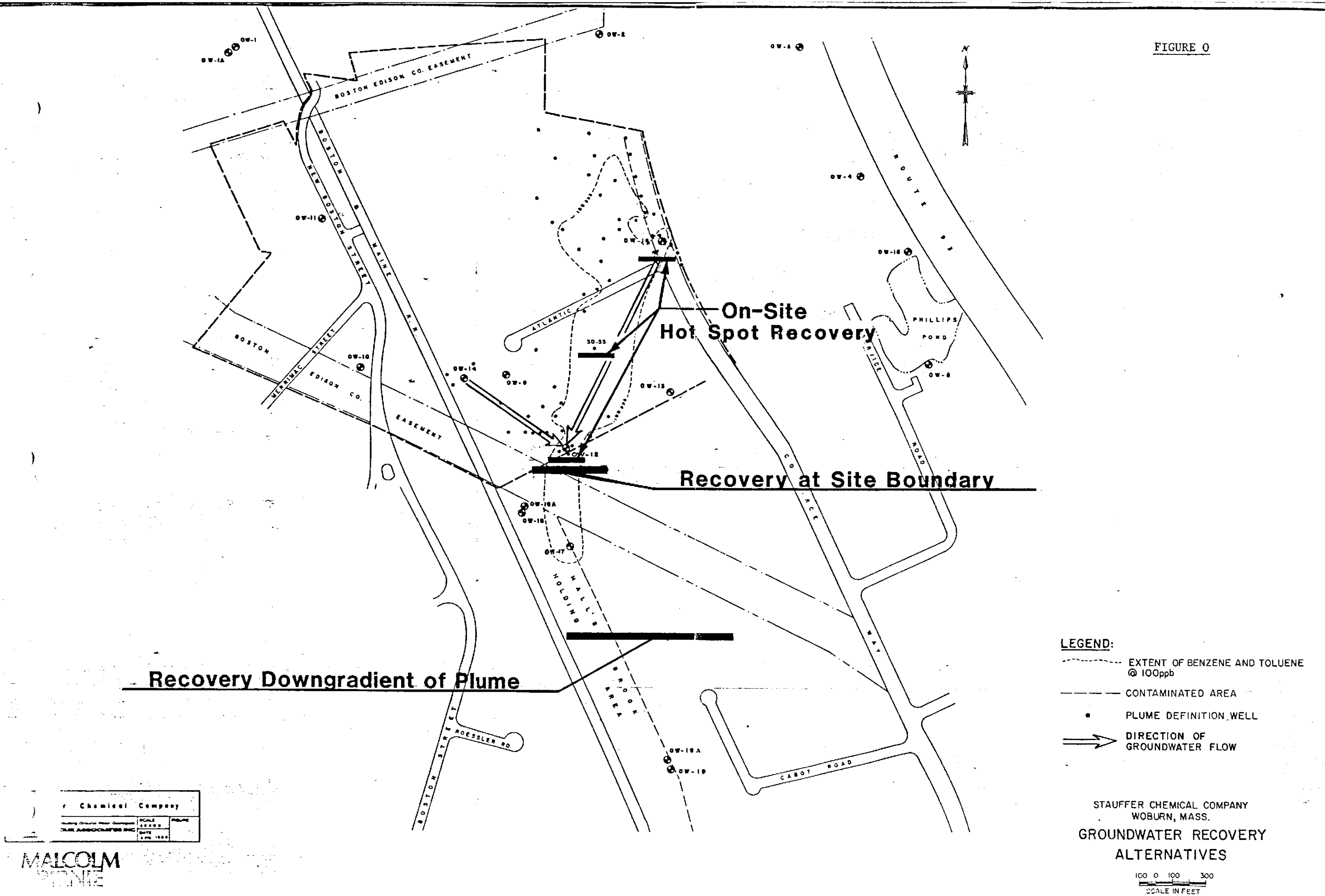
The cost estimate of \$3.6MM includes \$1.25MM captial and \$2.36MM for operating, maintenance, and monitoring for 15 years at 12% interest and 6% inflation. It is within EPA's cost estimate guidelines of -30 and +50% accuracy (Appendix I).

I. Other Viable Options Considered

Pump at Leading Edge of Plume

This option would provide greater certainty that the closed G & H wells would not receive levels of benzene in excess of the EPA SNARL, since virtually all the contaminated water will be extracted and dischar-

FIGURE O



MALCOLM PIRNIE

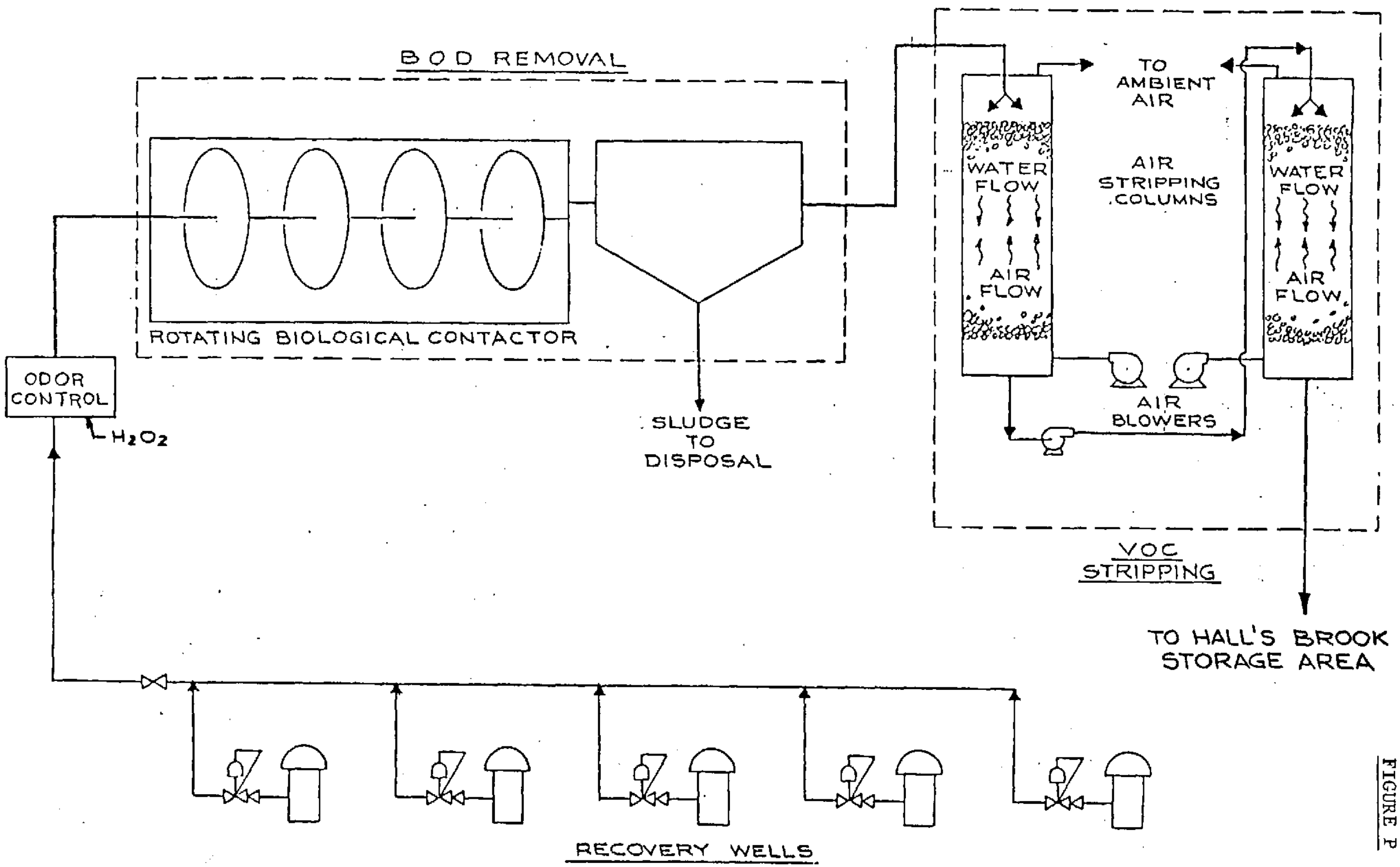


FIGURE P

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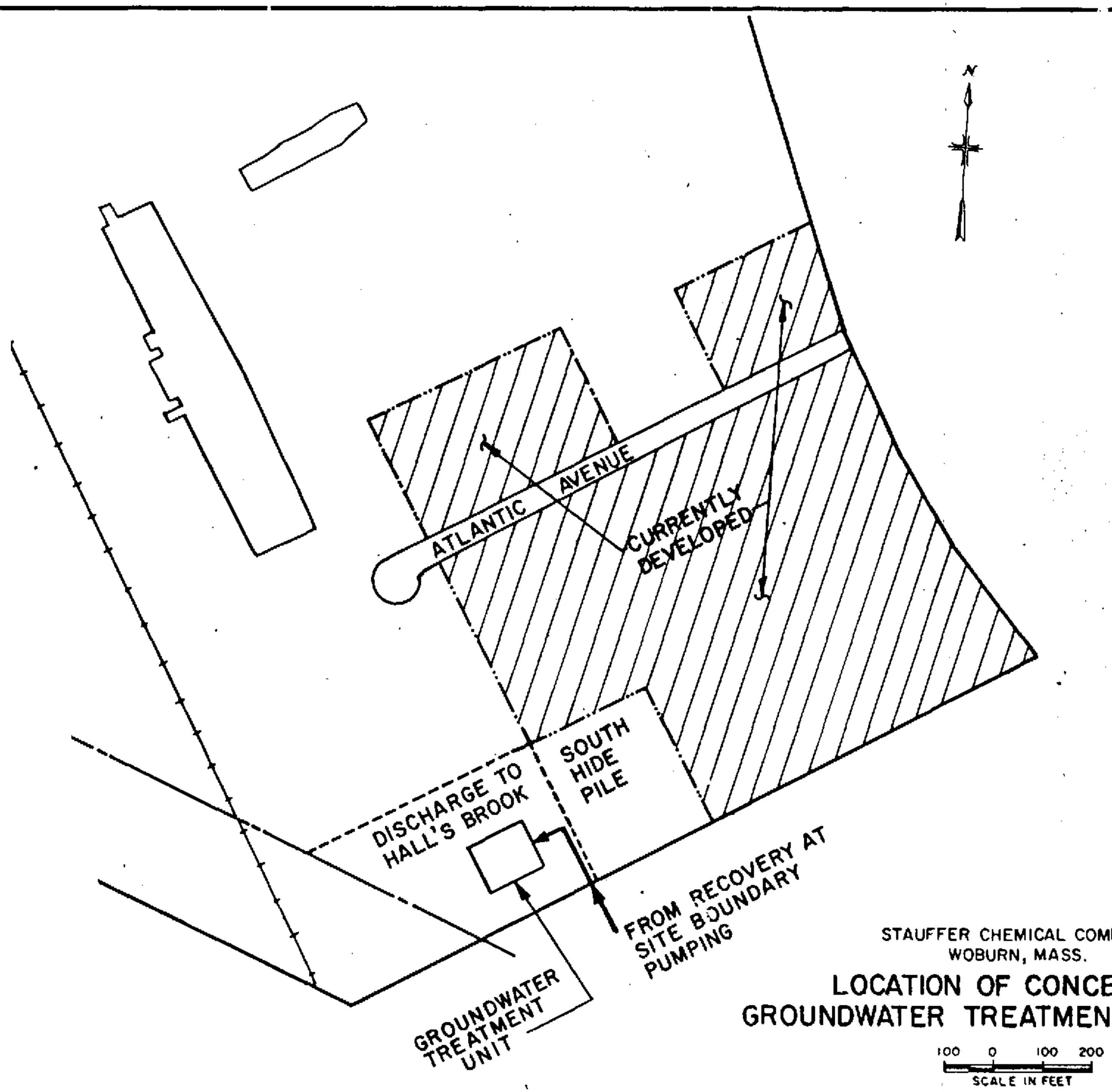
GROUNDWATER TREATMENT
FLOW SCHEMATIC FOR OPTION 2
(DOWNGRADIENT OF SITE RECOVERY)



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WOBURN, MASS.

LOCATION OF CONCEPTUAL GROUNDWATER TREATMENT FACILITIES

MALCOLM PIRNIE

FIGURE Q

ged to surface waters. However, at this pumping point (Figure O) zinc levels up to 47 ppm (which, if left uncontrolled would not exceed secondary drinking water standards at Wells G & H (Appendix A)) would require a complex, costly sulfide precipitation process to permit the discharge to the surface water in compliance with aquatic water quality criteria. To gain the greater certainty of protection for G & H wells which are closed due to contamination from other sources, at an additional cost of $7MM and a less reliable operating system is not considered cost effective.

Pump at Localized Areas of Elevated Benzene Levels

This option requires the least cost treatment system and time to completion. However less than 80% of the benzene can be captured. It is uncertain if the benzene left in the groundwater will disperse to levels less than the EPA SNARL at G & H wells. For this reason, this alternative was rejected.

2. EAST HIDE PILE ODOR EMISSIONS

A. Problem

The Arthur D. Little odor survey and neighbor complaints confirm the site has periodic severe odor emissions.

The Remedial Investigation and A.D. Little odor survey (Appendix F) identified the principal sources of site odor as the east hide pile. The south hide pile, west hide pile and east central buried hides were evaluated and considered not significant odor contributors. The south hide pile and east hide pile were found to have no measurable gas flows. The west hide pile was found to have a measurable gas flow, but very low odor causing components in the vented gases (i.e. average of only 55 ppm H_2S (Remedial Investigation Report, Appendix I, Table 2 and 2.2)).

The east hide pile was found to have appreciable gas emissions, which contained up to 5% H_2S and about 500 ppm mercaptans. The unabated "worst case" emissions were estimated to total up to 80 ACFM from the entire pile. The causes of the emissions are believed to be rapid barometric pressure flucuations, collapse of unstable side slopes, increases in site water table and rainfall infiltration. Air modeling calculations based on worst case emissions (Appendix C) and the A.D. Little Survey (Appendix D) showed the unabated east hide pile emissions frequently exceed odor detection levels and could lead to neighbor complaints.

B. Objectives

The remedial action objectives is to provide a control system to ensure odors generated at the site are non detectable.

C. Viable Remedial Options	Capital & O/M Costs

The viable remedial options identified in Malcolm Pirnie's ranking are as follows:

1. Dewater pond, grade slopes, cap with 20 mil PVC liner and cover with 30" soil/fill/ gravel and vegetate surface.	$1,860,000
2. Alternate 1 plus 12" layer of pea gravel with embedded 6" PVC pipe gas collection system, blower and activated carbon adsorption system.	$2,660,000
3. Alternate 1 plus 12" layer of pea gravel with embedded 6" PVC pipe gas collection system blower and thermal oxidation system.	$3,000,000

Operating and maintenance costs are for 15 years at 6% discount. Details of cost estimates are in Appendix I.

D. Recommended Action

It is recommended that Alternate 2 or 3, both of which should achieve 100% removal of odors, be implemented for east hide pile emissions. The two alternatives would both require the following cover/cap construction on the 3.8 acre east hide pile:

- Dewater pond between east and west hide pile to lower water table below bottom of the hide pile by rerouting/draining wetlands area near East Pile.
- Stabilize sides by grading to a 3:1 slope (common design standard), using the south hide pile as fill and purchasing additional fill as needed.
- Grade sides and top.
- Cover with 12" layer of pea gravel with embedded 6" PVC gas collection piping. Install 20 mil PVC liner. (See Figure J).
- Cover with 6" of sand.

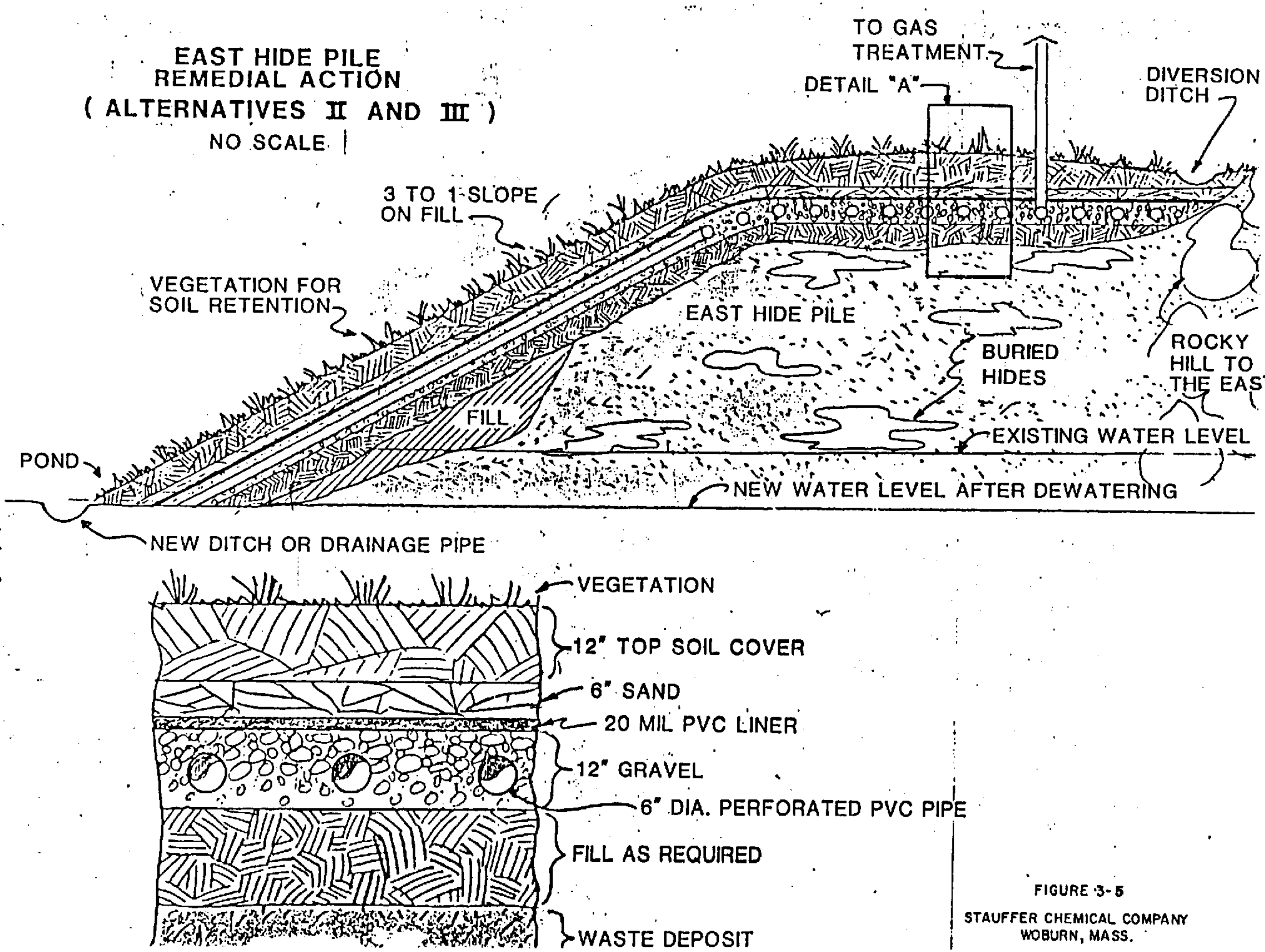

FIGURE 3-5
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WOBURN, MASS.

FIGURE J

44-9

- Cover with 12" of fill.
- Cover with 6" of top soil and vegetate.
- Install 20 to 100 ACFM blower and pressure control system to maintain constant slight vacuum in gas collection piping (Figure K). A 1000 ACFM supplementary blower would be included to assure adequate gas distribution in a carbon unit.

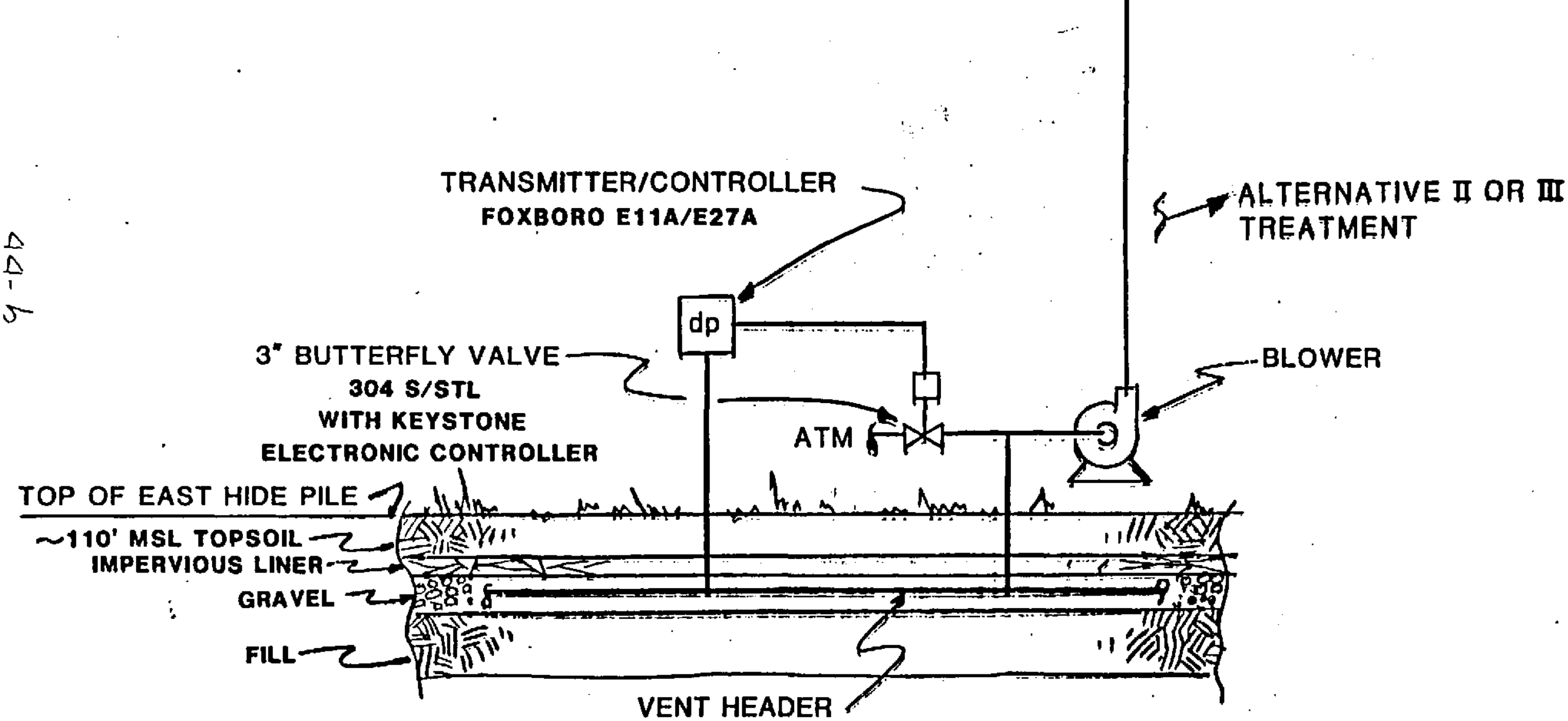
The construction of this control system should not create significant odors since the east pile will not be disturbed and the relocation and covering at the south pile will be completed during cold weather.

Of the two choices, Alternate 2, carbon adsorption (Figure L), is lower cost and slightly more reliable from an operating standpoint because of less equipment and instrumentation than thermal oxidation (Figure M). However, if the east hide pile emissions significantly exceed 2 ACFM or 2% H_2S the cost and operating reliability shift to favor thermal oxidation. The reason is that a higher H_2S loadings would increase carbon adsorption cost due to a larger carbon system or more frequent regeneration and additional support equipment. If thermal oxidation is needed, high gas volumes should provide sufficient methane for complete combustion without auxiliary fuel. Therefore, it is planned to cover/cap the east hide pile, measure emissions for 3 to 7 weeks and then select carbon adsorption or thermal oxidation based on the emissions measurements. (Schematic of Systems, Figures L & M, are shown on the following pages).

The conceptual design basis is 2-5 ACFM at 2% H_2S which represents the estimated average emission based on the remedial investigation find-

EAST HIDE PILE VENT CONTROL
(VENT TO CONTROL)

THE CONTROL SYSTEM WILL MAINTAIN A CONSTANT INTERNAL PRESSURE BELOW THE LOWEST WOBURN BAROMETRIC PRESSURE



NO SCALE

FIGURE K

FIGURE 3-6

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44-6

ALTERNATIVE II
(CARBON ADSORPTION)

NO SCALE

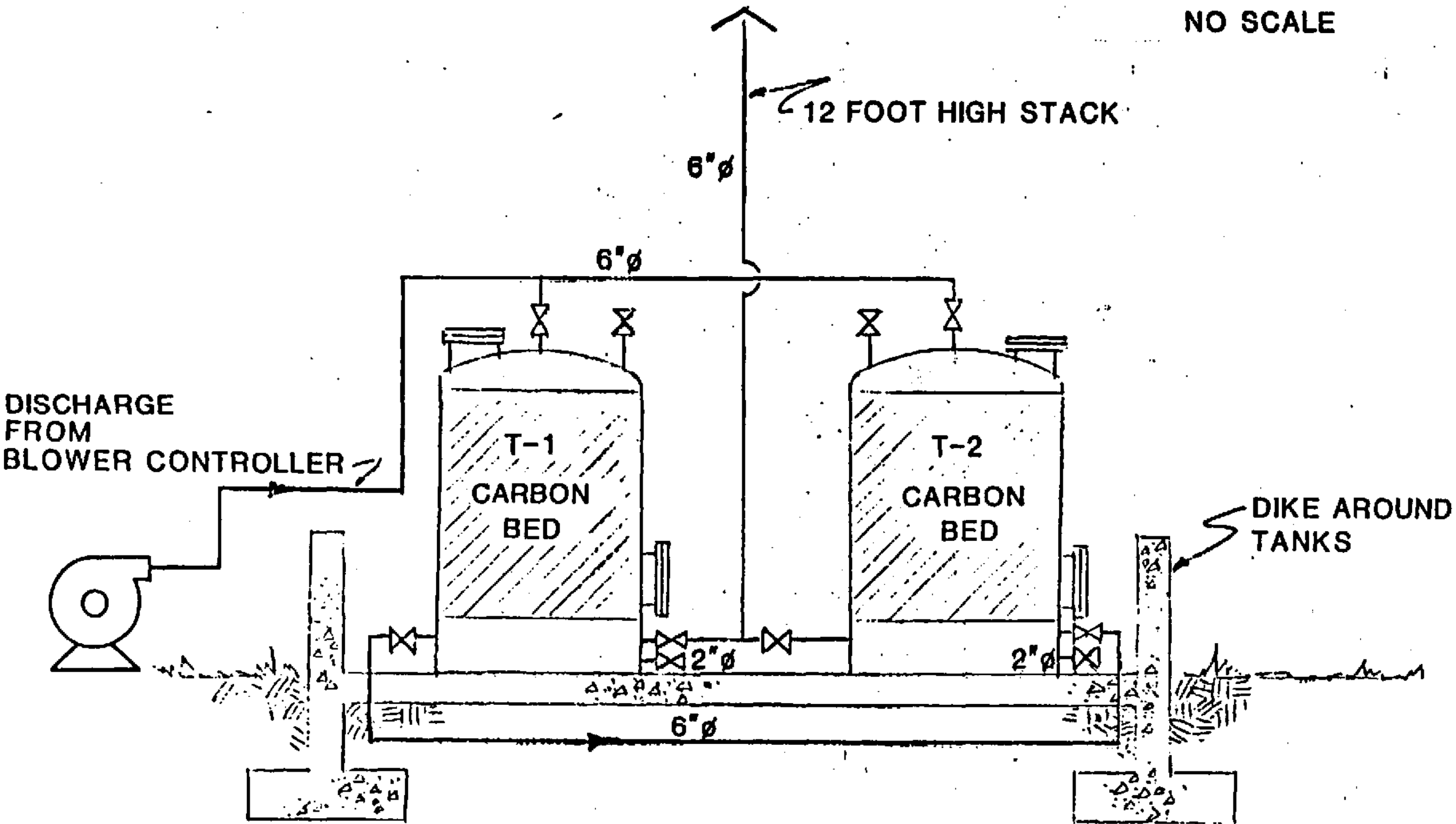

FIGURE L

T-1 & T-2   8' DIA. x 6' HIGH 316 S/STL. WITH TOP MANHOLE, SIDE MANHOLE, FLUSH BOTTOM DRAIN, WITH INTERNAL SCREEN TO SUPPORT 6000 LBS. CALGON TYPE IVP CARBON BED

FIGURE 3-3

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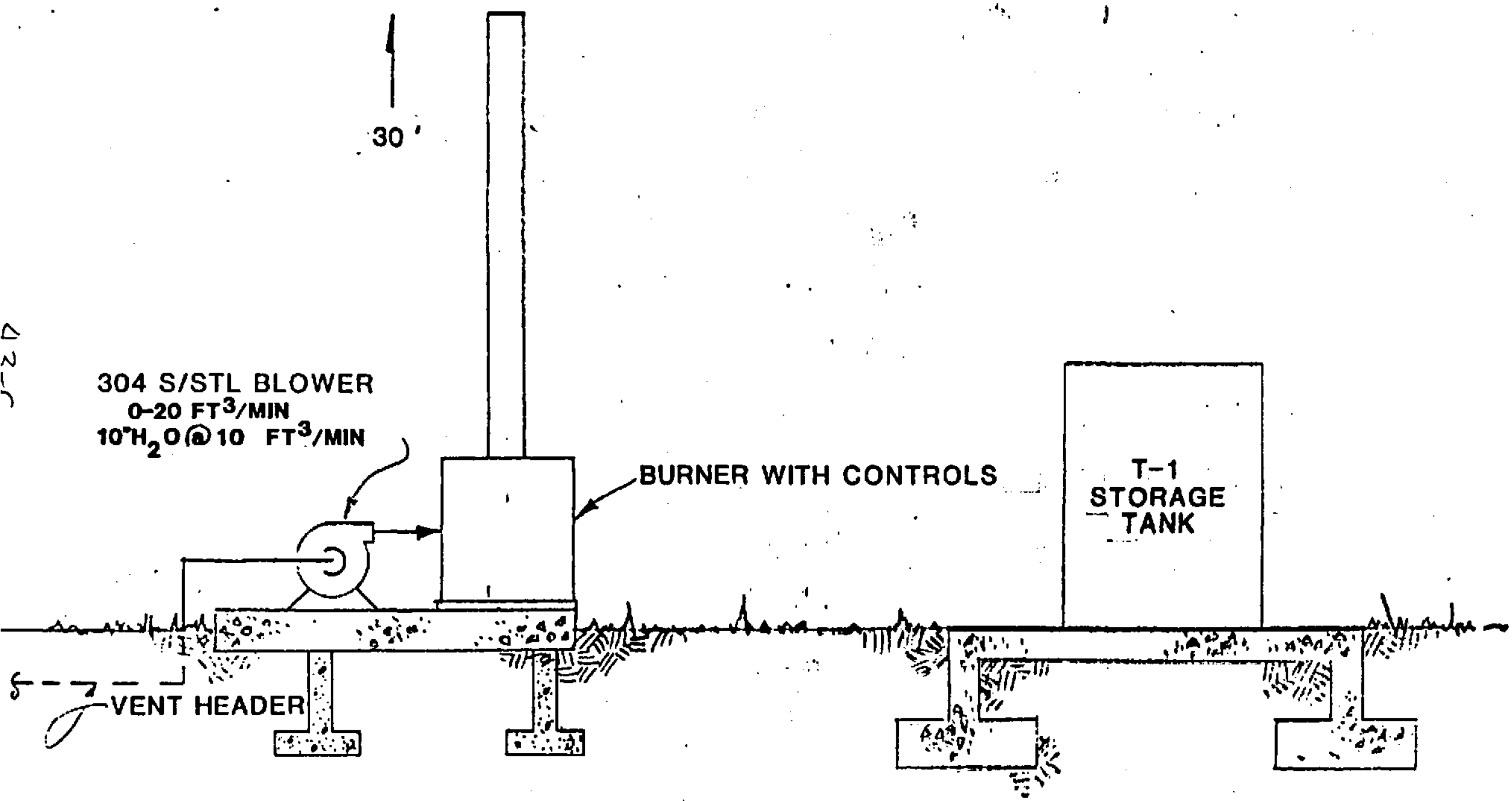
ALTERNATIVE III
(THERMAL OXIDATION)
NO SCALE



T-1 3000 GAL. C/STL
PROPANE STORAGE TANK

FIGURE 3-4

STAUFFER CHEMICAL COMPANY
WOBURN, MASS.

FIGURE M

ings. This estimate is believed to accurately represent emissions after capping and dewatering removes the causes of gas emission surges, e.g., sides collapsing, water intrusion, rapid barometric pressure drops.

The activated carbon system will require regeneration with a caustic solution wash once every year and result in 40,000 lbs/year disposal of dilute caustic solution. The thermal oxidizer will require no disposal of wastes since no residue will remain.

E. Permits

Massachusetts Air Regulations Section 7.09U require that no odor generating operation cause or contribute to a condition of air pollution. The activated carbon system will not emit detectable levels of H_2S or volatile organics, it will comply with requirements and meet primary ambient air standards for hydrocarbons of .24 ppm maximum 3 hours. The emission from the thermal oxides will be SO_2, CO_2 and H_2O. The SO_2 will be less than the 2.5 tons/yr SO_2 cutoff for requiring registration of the source. However, Ma. DEQE may still require permitting.

F. Cost

The cost of these options range from $2.6MM to $3.0MM consisting of up to $2.5 MM capital and $0.5MM operating and maintenance for 15 years at 6% discount.

G. Other Viable Options Considered

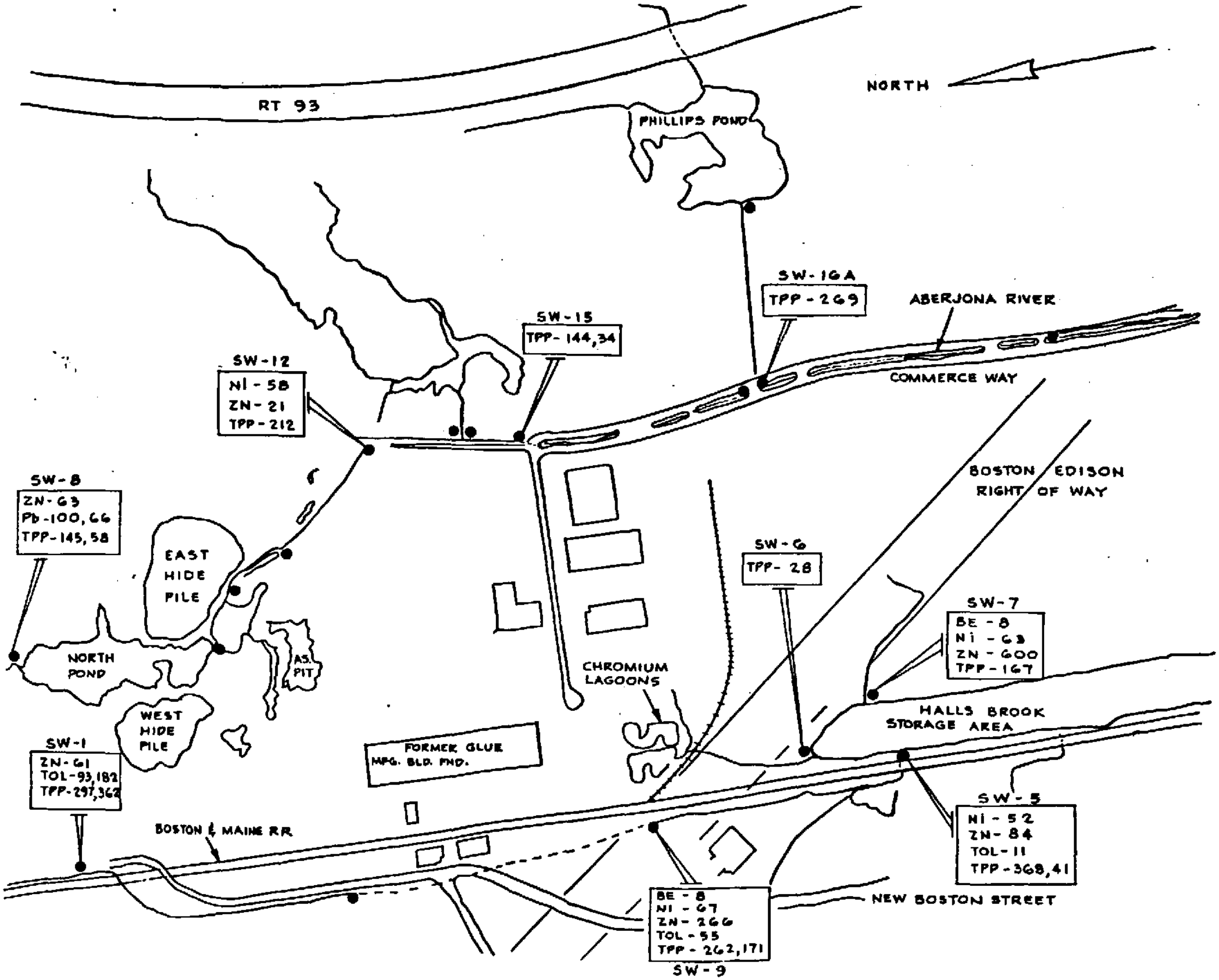
Alternative 1, which is to dewater the area, slope the sides and cap with a PVC liner and 30" of soil/fill/sand is not considered acceptable because of higher environmental risk. The impermeable PVC cover will contain the gases generated from anaerobic decomposition of the hide waste. Accumulated gas pressure must be relieved through escape at the outer edges of the liner, through holes in the liner or by escaping downward to dissolve in groundwater. While it is possible none of these gas releases will cause noticable odor in the surrounding areas, this is uncertain and it poses measurable risk of being an unacceptable solution.

3. WASTE DEPOSITS AND CONTAMINATED SOILS WITH LEVELS OF CHROMIUM, ARSENIC AND LEAD ABOVE SAFE LEVELS FOR DIRECT CONTACT

A. Background

The remedial investigation included extensive soil and waste deposit sampling, analysis, and surveys. The report found about 53 acres contaminated with greater than 100 ppm of chromium, arsenic, lead or zinc (Figure E), and about 20 acres of buried waste animal hides containing elevated levels of chromium commingled with other metals. The contamination was found in the top 2 feet of soil and to depths of up to 10 feet. About 10-15% of the wastes lie below the high water table. The hide wastes are located in 3 relocated piles, East, West and South and one undisturbed burial area - the East Central area (Figure D). The East pile is not considered under this section since the remedial action recommended to address odors will mitigate threats of heavy metals contamination from that source.

The heavy metal contaminants have been found to be highly immobile in the Woburn soil and waste matrix. RCRA Extract Test results demonstrate that the areas with the highest concentrations of lead, arsenic and chromium do not exceed current RCRA extract standards. Also although the wastes have been on the site for up to 100 years, groundwater (Figure H following Page 29) and surface water monitoring (Figure I) data have found no significant evidence of contamination from these wastes. Based on Roux Associates' groundwater dispersion model, it is extremely remote that leaching of heavy metals from onsite wastes would lead to metals ap-



TOL - TOLUENE PPB
ZN - ZINC PPB
BE - BERYLIUM PPB
NI - NICKEL PPB
Pb - LEAD PPB
TPP - TOTAL P.P. ORGANICS PPB

FIGURE 1

● SURFACE WATER SAMPLING LOCATION

LOCATION 19 NOT ON DRAWING

(19) ZN - 138
Pb - 121
TPP - 130, 431

FIG. 3

SURFACE WATER (SW) SAMPLING LOCATION

- AUGUST 1982 AND MARCH 1983 SAMPLING

pearing in Wells G & H above drinking water standards. Nevertheless, the recommmended groundwater remedy will intercept all the groundwater leaving the site, which eliminates this threat.

B. Problem

The problem being addressed is the potential for direct human contact with surface soils (0-2 feet) containing greater than 1000 ppm As, 1000 ppm Cr or 600 ppm lead. These levels were selected based on the endangerment assessment (Appendix F). There is also a remote threat of contaminant erosion to surface water leading to downstream exposure to As, Pb, and Cr at unsafe levels. Therefore, to assure that an adequate vegetative cover is sustained to prevent erosion of near surface soil, phytotoxic levels of arsenic (300 ppm - Appendix E) need to be covered. Figure F (following Page 15) shows the 43 acre area that contains levels of As, Pb and Cr in the top two feet at levels above 300, 600 and 1000 ppm respectively. There are also sewer and water lines buried in waste deposits which, during repair, might require disposal and handling precautions (Appendix H).

C. Objective

The objective of the remedial action for contaminated soil is to minimize the threat of direct contact with levels of arsenic, lead and chromium greater than the calculated safe levels, minimize future land use restriction and reduce the threat of erosion of wastes to surface water.

D. Viable Alternatives

The Malcolm Pirnie Screening and Ranking section of this report identified the following ten viable alternatives:

Cover about 70 acres containing greater than 100 ppm Cr, As, Pb with	Capital plus O/M Costs
1) 2 feet of impermeable clay, 6 inches of soil, and vegetate	$23,600,000
2) 6 inches of clay, 18 inches of fill, 6 inches of soil, and vegetate	$13,300,000
3) 2 feet of fill, 6 inches of soil, and vegetate	$ 9,000,000
4) A 20 mil synthetic impermeable cover, 24 inches of sand and fill, 6 inches of soil, and vegetate	$11,200,000
5) 6 inches of soil, deed restriction, limited excavation and vegetate	$ 5,000,000
Excavate/Relocate Waste Deposits and Contaminated Soil	
6) Construct a RCRA landfill onsite (27 acres), excavate, and place 68 acres (1,000,000 yd^3) of waste in landfill	96,000,000
7) Excavate 50 acres (459,000 cu yds), relocate/consolidate to 15 acres, cover with 20 mil PVC cover with 24 inches sand and fill and 6 inches soil, vegetate, and backfill excavated area	$19,000,000
8) Same as above except without backfilling	$11,000,000
Protect against direct contact of soil in the top two feet with 300 ppm As, 600 ppm Pb, 1000 ppm Cr	
9) Fence to prevent access/apply deed restriction, excavate limited areas	$ 3,000,000
10) Cover 43 acres with 24 inches of fill, 6 inches of soil and vegetate	$ 6,500,000

The operating and maintenance costs are for 15 years at 6% discount. Details are in Appendix I.

E. Recommended Action

The recommended remedial action is to cover the 43 acres of contaminated soil (Figure F) containing As, Pb and Cr in the top 2 feet of soil at levels exceeding 300, 600 and 1000 ppm respectively. This action was selected because it assures attainment of the remedial objectives. It removes the threat of direct contact exposure to levels of arsenic, chromium and lead that might cause adverse health effects. It minimizes restrictions on property use since the soil cover can be disturbed (with appropriate precautions) during site development without compromising its integrity. Finally, it provides for support of a healthy vegetative cover which reduces the potential for erosion of wastes to the surface water or exposing contaminated soil.

This action does not comply with RCRA interim status cover requirements. The RCRA cover is intended to minimize rainwater infiltration and thereby leaching of contaminants to groundwater. However, the remedial investigation, environmental impact assessment and endangerment assessment have shown that leaching of heavy metals is not a problem at Woburn. In addition, the design of the groundwater remedy is such that it prevents the migration of any leached metals (should there be any) to G & H wells.

F. Description of the Recommended Action

About 43 acres shown in Figure F have been determined through soil sampling and analysis to contain greater than the calculated safe levels for direct contact with chromium, arsenic and lead. This action will cover the 43 acres with 30" of soil and vegetate. The 43 acres were conservatively estimated with a 10% - 30% over coverage to assure adequate protection. About 200,000 cubic yards of soil will be delivered in 15 cubic yard trucks to the site during evening hours to avoid traffic congestion. The delivery will take less than one year. Minimal deed restrictions on the property will be needed to assure the cover, if disturbed, is properly repaired and excavation of waste deposits are performed safely.

The action also provides for draining the wetlands on the site and routing the surface water to prevent cover washout and erosion. The Screening and Ranking Section describes the drainage pattern in more detail and concludes that downstream flooding will not occur. The action also provided funds for disposal in an approved facility of contaminated soil excavated when buried sewer and water lines are repaired (Appendix H).

G. Permits

Draining the wetlands, rerouting surface waters and spreading this quantity of clean fill will require approval of local zoning and wetland authorities and possibly the Army Corps of Engineering if significant dredging or filling in wetlands is required.

H. Costs

The estimated cost of this option is $6,500,000 consisting of $5,300,000 capital for the soil cover, $200,000 for disposal of contaminated soil generated during buried sewer and water line repairs and $1,000,000 for maintaining the cover for 15 years at 6% discount rate. The estimate provides a 40% contingency and used conservative unit cost estimates. It is accurate to -30%, +50%. (Appendix I).

I. Other Viable Options

The other viable options not selected are as follows:

1) 20 mil PVC cover over site areas with greater than 100 ppm Cr, Pb, As

This option would most closely satisfy RCRA interim status cover requirements if 100 ppm is considered RCRA hazardous. However, the additional expense of $5,000,000 spent simply to satisfy RCRA rules developed to minimize leaching of wastes when such leaching is clearly not a problem was not considered cost effective. An impermeable cover would provide an immeasureably small improvement in protection of the public health and environment, since

- Heavy metal waste on the site are highly immobile as evidenced by groundwater monitoring results and RCRA extract tests.
- The remedy required to clean up the benzene and toluene in groundwater will preclude site metals from ever reaching Wells G & H in the future.
- An adequate seal for the cover will be difficult to achieve since it must be fitted around or under railroad tracks and buildings.

An impermeable cap would probably preclude future site development to assure maintenance of the integrity of the cover.

2) 24 inch clay cover and 6 inches soil over 68 acres with greater than 100 ppm Cr, As, Pb

This option was included because it might satisfy RCRA interim status cover requirements. However, it costs $17,000,000 more than the recommended action because large quantities of clay are unavailable in the vicinity of Woburn and bentonite must be shipped from Wyoming and mixed with Woburn area soil. It suffers from all the same drawbacks as Alternate 1 (above) and costs substantially more. It was, therefore, dismissed.

3) <u>6 inches of clay cover, 18 inches of fill, 6 inches of soil and vegetate the 68 acres with greater than 100 ppm Cr, As, Pb</u>

This option was evaluated because it might satisfy RCRA policy. However, it costs more than the 20 mil PVC cover and has all the same drawbacks. In addition, the integrity of the cover would be questionable due to its thinness.

4) <u>30 inches of soil cover the 68 acres greater than 100 ppm Cr, As, Pb</u>

This option does not satisfy RCRA and the added $3,000,000 cost does not measurably reduce the direct contact or surface water erosion threats beyond those contained in the recommended action.

5) <u>6 inches soil cover, fence deed restrictions, limited excavation of "Hot Spots"</u>

This option is cost effective and would protect against direct contact hazard initially. However, freeze/thaw cycles might, according to EPA, move wastes to the surface in time re-introducing a contact hazard at the site. It also does not satisfy RCRA policy.

6) <u>Excavate 70 acres (1,000,000 cu yd), relocate wastes to RCRA landfill constructed onsite, and backfill</u>

This option would satisfy RCRA, eliminate the potential direct contact hazard at the site and prevent leaching/erosion onsite. The cost is an order of magnitude greater than the recommended action and 4-5 times more than other options. Additionally, this option would severely disrupt the surrounding community requiring about 67,000 truckloads of fill over a five year period. During the course of implementation, roads would probably require replacement and odors would be difficult to control.

Upon completion, fifteen acres would remain unsuitable for development. This solution is unpracticable and not cost effective. In addition, it offers little gain in benefit to public health or the environment over the recommended action.

7) Excavate about 40 acres (500,000 cu yd), and consolidate on 15 acres of hide areas and cover with 20 mil PVC 30" of sand and fill, vegetate

This option might satisfy RCRA interim status cover requirements and would free up some land for unrestricted development. However, the $13,000,000 additional expenditure does not improve the protection of public health from direct contact or reduce the threat to surface water significantly more than the recommended action. There are no measurable environmental benfits. It suffers from most of the disadvantages of the 20 mil PVC cover and onsite RCRA landfill options but does allow site development on some of the property with few restrictions. Sealing the cover will be simpler. This option would again severely disrupt the community with 50,000 truckloads of fill delivered over a three year period. Odor will be difficult to control during implementation.

8) Consolidate without backfill

This option has all the advantages and disadvantages of the consolidate with backfill option (above) except that community disruption is minimized. It was presented since the cost is significantly less than if backfill is required. However, it provides little additional benefit to public health or the environment over the recommended action, has most of the disadvantages of consolidation and would leave an unsightly property that is poorly suited to future use.

9) <u>Excavate 70 acres (1,000,000 cu yd) with greater than 100 ppm Cr, As, Pb, dispose offsite backfill</u>

This option has all the disadvantages and problems of the onsite RCRA landfill and costs an order of magnitude more than the recommended action, and only moves the waste care problems from one place to another. In addition, availability of a suitable offsite disposal facility is uncertain.

1.0 Remedial Action Screening and Ranking

Description and Methodology

This report evaluates remedial alternatives to mitigate Worburn Site environmental problems identified by the Remedial Investigation Report:

- Ground water with benzene and toluene on site and immediately downgradient.
- Odorous gas emissions from East Pile.
- Waste Deposits and soils contaminated with Heavy Metals.

Although interrelationships exist between the three problems is necessary, from a readability standpoint, to develop, evaluate, and rank the remedial alternatives on a problem-specific basis. This presentation format should not be mistaken to imply that consideration of the interrelationships was ignored. In any remedial action, careful consideration was given to predict potential ramifications in all affected media.

A 5-step procedure has been utilized for each of the three problems to determine the response actions most appropriate to the Woburn site. This procedure allows alternatives to be selectively screened during each step. In this manner, a logical convergence of appropriate remedial action occurs. The 5 steps involved in this procedure are as follows:

- Step 1: Identification of General Remedial Technologies
- Step 2: Identification of Remedial Technologies Specific to the Woburn Site
- Step 3: Screening of Viable Alternatives
- Step 4: Detailed Analysis of Alternatives
- Step 5: Ranking of Viable Alternatives

Sections 2, 3, and 4 of this report address the environmental concerns associated with ground water, air and soils, respectively. Since the 5-step procedure outlined above is utilized in each section, a convenient cross reference numbering system is established. For example, Section 2.1 identifies general remedial technologies for ground water while Section 3.3 screens viable alternatives for odor control. An in-depth discussion of each step in the procedure will conclude this section.

Step 1

A detailed literature search of EPA remedial documents, technical journals, handbooks and remedial manuals was made, in conjunction with experience gained on similar projects, to identify technologies of potential value on a general media basis. Virtually all identified technologies were included at this stage unless the remedial method was still in the experimental stage.

Step 2

A detailed review of existing conditions at the Woburn site was made to identify site specific areas to which outlined remediation techniques from Step 1 are applied. Existing conditions were determined from site visitations and Phase I and Phase II investigations.

Step 3

In an effort to establish a means of evaluating the effectiveness of the candidate remedial methods, Section 300.68(i) of the NCP was reviewed. In accordance with the NCP, four criteria were selected to evaluate the effectiveness of the various remedial methods in meeting general site remedial objectives. The four evaluation criteria include:

- Cost (order of magnitude)
- Negative environmental impact potential
- Environmental effectiveness
- Feasibility and reliability

The four evaluation criteria to be used in the initial screening of alternatives are described below.

Cost - For each alternative, the cost of installing or implementing the remedial action will be considered, including operation and maintenance costs. An alternative that exceeds the costs of other alternatives by an order of magnitude but still does not provide substantially greater public health or environmental benefit will be excluded from further consideration.

Negative Environmental Impact Potential - The effects of each alternative will be evaluated to determine if the potential alternative implementation has any adverse environmental impacts. If an alternative has significant adverse environmental effects, it will be excluded from further consideration.

Environmental Effectiveness - The effects of each remedial alternative will be evaluated to determine whether the alternative is likely to achieve adequate control of source material thus minimizing the threat of harm to public health, welfare or the environment. Only those alternatives that effectively contribute to protection of public health, welfare or the environment will be considered further.

Feasibility and Reliability - Alternatives must be feasible for the location and conditions of the contaminant release, applicable to the problem, and represent a reliable means of addressing the problem. If an alternative requires the implementation of unproven or unreliable technology, or if there exists some doubt as to whether the method will efficiently operate under expected site conditions, it will be excluded from further evaluation.

The purpose of the screening of remedial alternatives is to identify any gross deficiencies that would eliminate a particular remedial method or alternative from further consideration for meeting the Woburn site specific remedial objectives. Those methods/alternatives identified as being deficient in their ability to meet general site remedial objectives will be omitted from further consideration.

Step 4

The purpose of the detailed analysis is to further reduce the potential alternative list and focus the detailed analysis on only those alternatives that are clearly applicable to Woburn site conditions. The detailed analysis will include expanded descriptions of the alternatives, and will culminate in a functional analysis of the alternatives that best address the functional areas.

Each of the potential remedial actions is evaluated (using the established criteria) for its ability to achieve site remedial objectives. The ability of each action to achieve the various objectives is then compared to the other alternatives. The process results in ratings for the ability of each alternative to attain the various objectives. A rating of one indicates that the alternative is poor in meeting a particular objective while five indicates that the alternative is excellent in meeting a particular objective. The rating numbers represent relative abilities of various alternatives to achieve site objectives and should not be considered absolute values. Rather, they should be used to select alternatives for subsequent detailed analysis.

A criteria weighting factor also is incorporated in the evaluation process in an effort to rank the criteria according to relative significance in accomplishing the site remedial objectives. The rating for an alternative is then multiplied by the weighting factor to produce a score for each criterion. All criteria scores for each alternative are ultimately summed to produce a total score that reflects the ability of each alternative to meet all of the remedial objectives.

The alternatives that have the highest ratings will be retained as the most viable remedial actions for specific functional areas. The viable alternatives will be evaluated in subsequent detailed analyses for the various functional areas. The final outcome of the functional analysis of remedial actions provides a recommended alternative based on environmental effectiveness.

Functional Analysis Evaluation Criteria

Five general criteria were selected to evaluate the level of the effectiveness of various remedial actions in meeting site remedial objectives. The five evaluation criteria include:

- Reliability
- Constructibility
- Implementation Time Frame
- Environmental effectiveness
- Future land use

Reliability - To be reliable a remedial method must be dependable, proven and recognized by the EPA (through the NCP) as an acceptable means to control hazardous waste sites. The remedial method or technology must also be applicable to the given site situation; therefore, it must be able to be successfully applied to a media and functional area, and remain operable in the on-site environmental conditions expected to occur throughout the life of the project.

Constructibility - To be constructible a method/technology must be able to be built or implemented using common, accepted engineering or construction methods. The degree of difficulty in the installation, mechanical work, or "building" the alternative will be reflected in this criterion. Additionally, the method or technology must be implemented without impairing or jeopardizing worker safety.

Implementation Time Frame - The implementation time frame of any remedial method or technology could ultimately affect its cost, environmental effectiveness and potential for site-related environmental impacts. Remedial alternatives that maximize short-term accomplishments and minimize the long-term monitoring and maintenance requirements are favorable. The impacts of the permitting process affect time and, therefore, are also considered in this criterion.

The implementation of a remedial action also depends on the acceptance of the action by the public in the local area. Since hazardous waste is a subject that has received significant local comment, it is important that any action taken meets the public's reasonable desires and reduces, as much as possible, the public's concerns of potential adverse health effects.

Environmental Effectiveness - The environmental effectiveness of a remedial alternative is the most important evaluation criterion. Operations that create additional adverse impacts or significant risk of impact should be avoided. The remedial actions should promote conditions consistent with applicable state and federal environmental standards and future land usage and development. In addition, the remedial actions should promote conditions that minimize the potential for exposure to the contaminants. Therefore, applicable technologies need to be evaluated on the basis of their ability to accomplish the remedial goals set forth earlier in the report.

The evaluation criteria will be used in the functional analysis of remedial actions for specific functional areas of the site. The results of the analysis will form an evaluation matrix that appears in each respective section. It should be noted that although associated costs are not included in the functional analysis of remedial alternatives, overall cost effectiveness will be considered in the next step. The functional analysis provides a qualitative method to screen a range of alternatives and to select those that best satisfy site objectives as outlined in the four (or five) functional criteria. The highest ranking alternatives from the functional analysis will subsequently be compared to determine how effectively site objectives are met on a cost basis.

It should be realized that the values of the functional ratings do not necessarily indicate that one particular alternative is the "best" overall solution to the problem. The purpose of the functional analysis is to screen alternatives, and once the "best" alternatives from the functional analysis are selected, costs should be compared to determine the cost effectiveness of the selected alternatives in solving overall site objectives.

Future Land Use - Since the future use of the site is an important factor, we have evaluated the impact of remedial actions on the development potential. This criterion was not included in the Consent Order but we believe it important enough to be considered in actions pertaining to contaminated soils. It will not be used as an evaluation criterion when considering ground water or air emissions since those actions have limited influence on development.

Functional Analysis Weighting Factors

Weighting factors vary from 0.5 to 2.0 in the functional analysis matrix. The variance in weighting factors represents a recognition of the relative importance of each of the criteria in meeting site remedial objectives.

A weighting factor of 2.0 was assigned to environmental effectiveness which establishes it as the most significant aspect of an alternative. A weighting factor of 1.1 was assigned to reliability due to its bearing on whether an alternative is environmentally effective or not. Two alternatives could be of equal environmental effectiveness; however, one alternative may require inordinate operational maintenance, a large margin of safety during design and operation, or operational complexities in achieving the same net result.

A weighting factor of 0.6 was assigned to constructability in recognition of the fact that, while some methods might appear environmentally effective, they cannot be easily constructed. However, many available and widely accepted engineering techniques use innovative construction for implementing programs under adverse conditions. Therefore, while constructibility is an important concern, it is not of the critical nature of the environmental effectiveness or reliability criteria. Deficiencies in the constructibility of an alternative can be overcome by thoughtful engineering design, but an environmentally ineffective or unreliable alternative cannot be easily designed to achieve the site remedial objectives.

Implementation time frame was assigned a weighting factor of 0.5 because, like constructibility, deficiencies in the alternatives due to implementation can be overcome by careful planning, contingency measures and development of a thorough work plan. Future land use was assigned a weighting factor of 0.5 because the development potential (or lack of it) is an important consideration for contaminated soil remedial alternatives.

Step 5

Associated costs for the selected remedial alternatives from Step 4 are considered in conjunction with results from the functional analysis to facilitate a final ranking of alternatives. Costs may be found in the attached appendix located at the end of this report.

2.0 Ground Water Remedial Program

Introduction

The purpose of this section is to develop a ranking of viable remedial alternatives that will mitigate ground water concerns at the Woburn site. Before discussing the remedial alternatives, it is appropriate to review what the chief ground water concerns are. This is best accomplished by summarizing the existing information.

Summary of Existing Information

The remedial investigation found levels of benzen and toluene at 30+ ppm on site and a few hundred ppb immediately downgradient of the site (Figure 2-1 following page). If left uncontrolled the benzene is projected to reach the currently closed Woburn Municipal Wells in about 25 years at levels up to 10 ppb and exceeding the current EPA Drinking Water Suggesed No Adverse Response Level (SNARL) of 6.7 ppb. (Appendix A.)

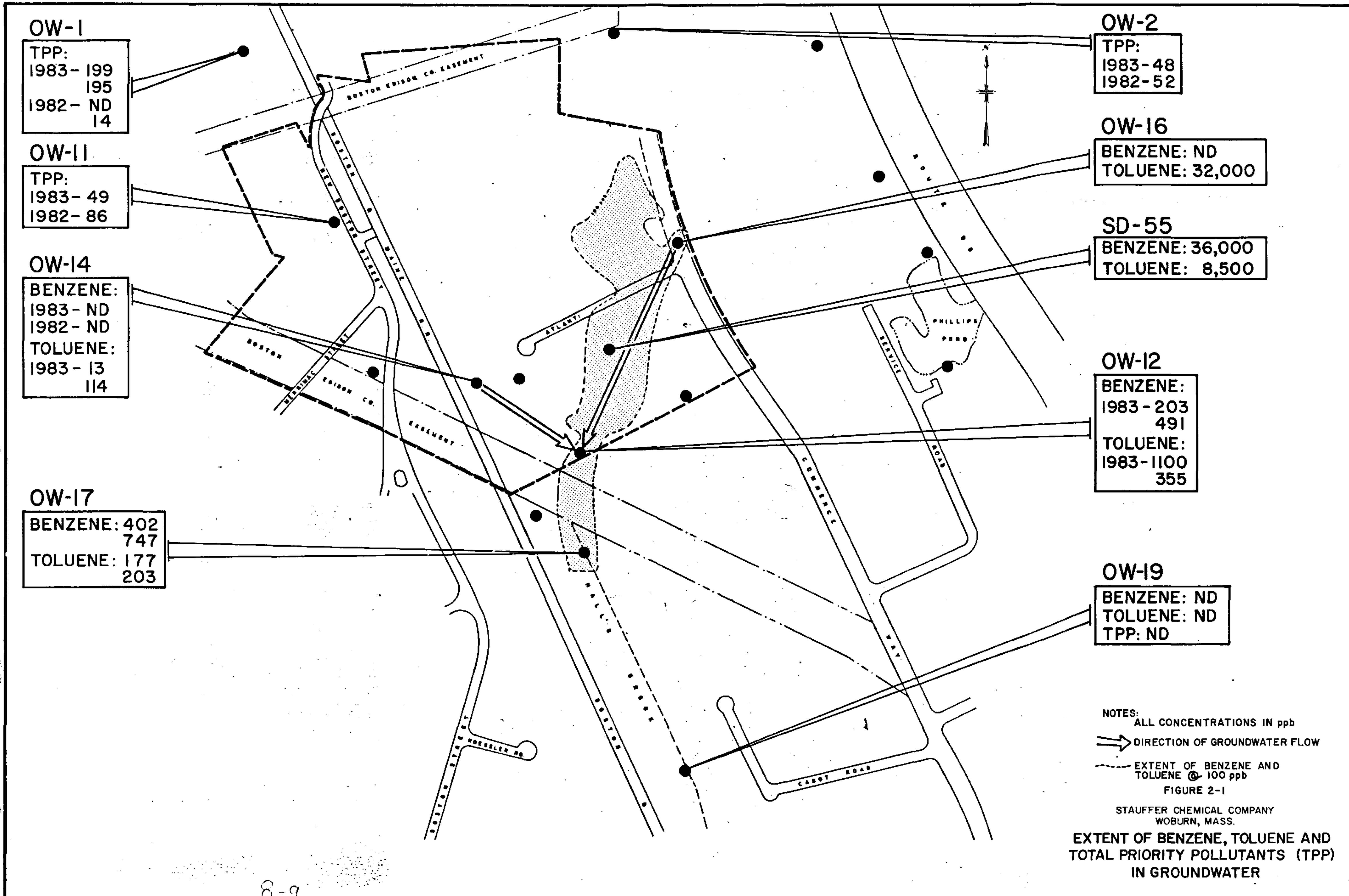


FIGURE 2-1

STAUFFER CHEMICAL COMPANY
WOBURN, MASS.

EXTENT OF BENZENE, TOLUENE AND TOTAL PRIORITY POLLUTANTS (TPP) IN GROUNDWATER

8-9

2.1 Ground Water Remedial Technologies

As explained in Section 1.0, General Procedures, a detailed literature search and review of past experience identified general technical approaches that are currently available for groundwater interception/recovery, treatment and discharge. The technniques included at this stage have not yet been scrutinized with regard to existing conditions at the Woburn site. Applicaton of these technologies to the Woburn site are identified in site specific alternatives found in Section 2.2. The applicability of certain techniques from a site-specific standpoint are reviewed in Section 2.3.

2.1.1 Ground Water Interception/Recovery

- Ground water flow barriers
  - Slurry walls
  - Grout curtains
  - Interception trenching
  - Bottom sealing
- Ground water pumping
  - Water table adjustment (extraction)
  - Plume containment (extraction of plume, treatment and recharge

2.1.2 Ground Water Treatment

- Permeable treatment beds
- Biological treatment
  - Suspended growth
  - Attached growth
- Chemical methods
  - Precipitation-flocculation/sedimentation
  - Neutralization
  - Chemical oxidation
- Physical methods
  - Air stripping
  - Carbon adsorption
  - Ion exchange

- Reverse osmosis

2.1.3 Ground Water Discharge

- MDC Sewer
- Ground Water Recharge
- Surface Water

2.2 Identification of Woburn Site Specific Remedial Action Alternatives

Based upon the currently available technologies, an extensive list of site specific remedial action alternatives were developed for ground water interception/recovery, treatment and discharge. In most cases, the site specific actions listed below are various applications of a single technology from Section 2.1. For example, differences in interception/recovery locations will be considered as separate actions in future analyses. If a fundamental disadvantage becomes evident with a general method, all permutations of that method will be excluded from future consideration.

2.2.1 Ground Water Interception/Recovery

- Slurry wall around site perimeter tied into possible underlying confining strata.
- Slurry wall at north end of site tied into possible underlying confining strata.
- Slurry wall across southern boundary of site tied into possible underlying confining strata.
- Slurry wall across southern boundary of site and along East and West site boundaries, south of hide piles to mid site and tied into possible underlying confining strata.
- Slurry wall across northern site boundary, extending along east and west site boundaries to mid-site and tied into possible underlying confining strata.
- Slurry wall around detected ground water plume near wells OW-12 and SD-55.
- Slurry wall across northern boundary and southern boundary of the site tied into possible underlying confining strata.
- Grout curtain around entire site anchored in bedrock.
- Grout curtain across northern boundary of site anchored in bedrock.
- Grout curtain across southern boundary of site anchored in bedrock.
- Grout curtain across southern and northern boundaries anchored in bedrock.

- Grout curtain around detected ground water plume near wells OW-12 and SD-55.

- Bottom seal under entire site by injection of a grout curtain base layer.

- Pump ground water via recovery well system along entire perimeter of the site.

- Pump ground water via recovery well system along northern boundary of the site.

- Pump ground water via recovery well system along southern boundary of the site.

- Pump ground water via recovery well system in the vicinity of the detected ground water plume near wells OW-12, SD-55, and OW-17.

- Pump ground water via recovery well system along the northern and southern boundaries of the site.

- Construct interception trench along northern boundary of site between East/West hide piles and wetlands.

- Construct interception trench along northern and southern boundary of site.

- Construct interception trench along southern boundary of site.

- Construct interception trenches downgradient of detected contaminant plumes near wells OW-12 and SD-55.

2.2.2 Ground Water Treatment(1)

- Treat recovered ground water with air stripping column for VOC removal.

- Treat recovered ground water with granular activated carbon (GAC) columns for removal of adsorbable organic compounds.

- Treat recovered ground water with powdered activated carbon (PAC) for removal of adsorbable organic compounds.

- Treat recovered ground water with oxidizing agent for odor destruction.

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1. Multiple treatment techniques may be used to assure adequate removal of all identified contaminants.

- Treat recovered ground water with ion exchange resins for cation and anion removal.

- Treat recovered ground water with suspended or attached growth biological reactors for removal of biochemical oxygen demand (BOD).

- Treat recovered ground water with air stripping column and with PAC.

- Treat recovered ground water with reverse osmosis for multi-compound removal.

- Treat recovered ground water with pH adjustment/precipitation-flocculation/sedimentation for metals removal.

- Install permeable treatment beds (GAC) downgradient of East and West Hide Piles.

- Install permeable treatment beds (GAC) downgradient of wells OW-12 and SD-55.

- Install permeable treatment beds (GAC) along downgradient boundary of site.

2.2.3 Ground Water Discharge

- Direct discharge to MDC sewer.
- Treatment, discharge to MDC sewer.
- Direct discharge to downgradient surface water body.
- Treatment, discharge to downgradient surface water body.
- Treatment, recharge to the site substratum.

2.3 Screening Methodology

Alternatives for the remediation of contaminated ground water which were identified in Section 2.2 were reviewed. As explained in Section 1.0, consideration was given to site conditions and the criteria from Section 300.68 of the NCP. Those remedial alternatives which were omitted from further consideration and the associated rationale are presented below:

GROUND WATER REMEDIATION METHODS
OMITTED FROM FURTHER EVALUATION

Ground Water Interception/Recovery

Remedial Method	Omission Rationale
1. Containment barriers, slurry walls or grout curtains with/ without ground water pumping	Feasibility and Reliability, Environmental Effectiveness, Cost: A slurry wall/grout curtain around entire site is not feasible as a result of the integrity of the bedrock floor underlying the site. The bedrock to the east, west, and south is frequently fractured, permeable and dips steeply under the site. This will not be suitable as a floor for a slurry wall or grout curtain. A slurry wall would significantly heighten the water table at the site and ground water pumpage would be required anyway. Permeabilities of sediments underlying the site and adjacent to the buried valley are low, so many wells would be required. A slurry wall/grout curtain upgradient of the site to reduce inflow of ground water is not feasible because most ground water flowing in the unconsolidated deposits under the site originates as precipitation on the site. Very little flow into the site occurs from unconsolidated deposits upgradient of the site. This would, therefore, have no effect on the migration of the benzene plume.

GROUND WATER REMEDIATION METHODS
OMITTED FROM FURTHER EVALUATION
(Continued)

Ground Water Interception/Recovery (Cont'd)

Remedial Method	
2. Water table adjustment to minimize flow through waste material	Environmental Effectiveness: Ground water flowing through the unconsolidated deposits underlying the site originates as precipitation. Very little water enters the site through unconsolidated deposits upgradient, so upgradient pumpage would a have negligible effect on total flow rate.

Ground Water Treatment

Remedial Method	Omission Rationale
1. Treat recovered ground water with ion exchange resins	Feasibility and Reliability, Environmental Effectiveness, Cost: Treatment via ion exchange requires pretreatment to remove solids, competitive ions and other resin fouling agents. Additionally, multiple exchange resins would be required to remove potential range of ions identified in soils and ground water. Pretreatment requirements, number and life expectancy of resin columns increases capital cost significantly above other alternatives without equivalent increase in environmental effectiveness.
2. Treat recovered ground water with reverse osmosis	Feasibility and Reliability, Environmental Effectiveness: Reverse osmosis has extremely stringent pretreatment requirements to avoid immediate failing. The pretreatment steps will improve water quality to acceptable levels (with the exception of arsenic removal) without incorporation of reverse osmosis or the costs inherent in the process. Therefore, increased cost with no significant increase in environmental effectiveness renders this process unnecessary for attaining required low effluent concentrations.

GROUND WATER REMEDIATION METHODS
OMITTED FROM FURTHER EVALUATION
(Continued)

Ground Water Treatment (Cont'd)

Remedial Method	Omission Rationale
3. Treat recovered ground water with PAC	Environmental Effectiveness, Cost: PAC offers no advantage over GAC for treatment efficiency in Woburn-type application. Filtration required prior to discharge and disposal of spent PAC after filtration increase O&M requirements and cost far in excess of GAC with no practical environmental benefits.
4. Permeable treatment bed for VOC, solids removal	Feasibility, Reliability, Environmental Effectiveness: Effectiveness of this technology is not well developed due to short circuiting/ channeling and nondistributed contact.

Ground Water Discharge

Remedial Method	Omission Rationale
1. Treatment, discharge to MDC sewer	MDC cannot accept additional flow until court-ordered mandates are in place
2. Direct discharge to MDC sewer	Same as above.
3. Treatment, discharge to aquifer upgradient via trench, pond or leach field	Feasibility and Reliability: Technically feasible only for small volumes of water such as would be generated by hot spot pump out. Greater than 50-75 gpm would overload the shallow aquifer and cause surface flooding. This is particularly a problem in developed areas.
4. Treatment, discharge to aquifer downgradient via trench, pond or leach field	Same as above except a slightly greater (100 gpm) quantity might be accomodated. However, extensive development in the area north of Mishawam Road limits space for recharge facility. Flooding of adjacent developed area is likely.

GROUND WATER REMEDIATION METHODS
OMITTED FROM FURTHER EVALUATION
(Continued)

Ground Water Discharge (Cont'd)

Remedial Method	Omission Rationale
5. Treatment, discharge to aquifer via well injection downgradient	Might accomodate up to 400 gpm and avoid flooding and land availability problems, but additional well costs and treatment (to avoid plugging) without any significant advantages.

Description of Retained Remedial Alternatives

The ground water remedial methods retained for further evaluation and the rationale for their retention are summarized below:

GROUND WATER REMEDIATION METHODS RETAINED FOR FURTHER EVALUATION

Ground Water Treatment

Remedial Method	Retention Rationale
1. Treat recovered ground water with air stripping column	Feasibility and Reliability, Environmental Effectiveness: Proven means of reducing VOC concentrations in ground water with little associated operational maintenance.
2. Treat recovered ground water with GAC column	Feasibility and Reliability, Environmental Effectiveness: Also a proven means of removing organics from ground water, although operational maintenance requirements include GAC column replacement, and regeneration or disposal.
3. Precipitation-flocculation/ sedimentation for metals removal	Feasibility and Reliability, Environmental Effectiveness: Metals removal by precipitation is a proven means of eliminating metals concentrations from ground water.
4. Ground water treatment with oxidizing agent for odor control	Environmental Effectiveness: Odor control may be required to prevent nuisance odor.
5. Ground water treatment with suspended or attached growth biological reactor for BOD removal	Environmental Effectiveness: BOD removal may be required to meet discharge standards for surface water discharge. Package plants such as rotating biological contactors (RBCs) can provide adequate treatment.

Ground water management alternatives applicable to Woburn site conditions are up- and down-gradient ground water recovery and certain treatment techniques. Ground water recovery alternatives include one on-site and two off-site pumping options. Retained treatment alternatives for ground water include: GAC columns, air stripping, precipitation-flocculation/ sedimentation, oxidizing agent addition and biological treatment. The type of treatment depends on where ground water recovery takes place and the ultimate location of discharge. If localized on-site hot spot ground water recovery (e.g., in the vicinity of Wells OW-12, OW-17 or SD-55) is determined to be an effective alternative, odor control may be required in addition to organics removal based on observations during the remedial investigation. On the other hand, if a broad-front ground water recovery system is recommended downgradient of the site, volatile organic removal could prove to be the only required treatment; however, odor control may be warranted based on future recovery well water quality analyses obtained.

2.3.1 Ground Water Interception/Recovery Alternatives

Ground water recovery alternatives included in the functional analysis are described in the following paragraphs:

- On-site, hot-spot recovery: This option involves selective placement of recovery wells in the vicinity of the highest detected concentrations of benzene. A pump-out system near SD-55 (see Figure 2-3) would be effective because benzene would be intercepted near its apparent source. One well pumping at 20 to 30 gpm for two or three months may be sufficient to remove the slug of benzene. Installation of two additional wells with a total pumpage of about 20 gpm would reduce the pump-out to one month. However, this localized pumpage would not collect benzene from other areas in the plume where it is less concentrated. Existing Wells OW-12 and OW-16 (see Figure 2-3) can also be pumped to remove benzene/toluene. It is estimated that they can be pumped at 10 to 20 gpm. This slug pump-out option would remove all of the ground water from within about 100 feet of the pumping wells or approximately 80 percent of the known benzene and a substantial percentage of the toluene in the ground water. This estimate is based on plume maps from March 1984, and assumes that contaminant slugs have not dispersed or migrated significantly since then.

  Pumping tests should be conducted at OW-12 and in a new well at SD-55 (see Figure 2-3) to determine their maximum effective yields. A pumping test has already been conducted on OW-16. It is estimated that 50-75 gpm would have to be withdrawn if all of the slugs are to be removed within one to two months.

  The short-term monitoring program for the hot-spot pumping program would include periodic analysis of pumped water to determine when the pumps can be shut off. A long-term, semiannual sampling and monitoring program for heavy metals and VOCs would be implemented. This program would include existing Wells OW-9, OW-12, OW-13, OW-16, OW-17, OW-18 and OW-18A. In addition, three new monitoring wells, one near SD-55, one immediately upgradient of OW-12 and one immediately downgradient of the pumping wells, would be installed and monitored.

- Recovery at the Site Boundary: Recovery of ground water immediately downgradient of the site boundary provides for removal of the contaminant plume thereby minimizing the potential for downgradient aquifer impacts. To properly install this system of wells, however, the width of the buried bedrock valley in the vicinity of OW-12 (see Figure 2-3) must be better defined.

  When the bedrock valley is defined, it will be necessary to install one 6-inch diameter pumping well and several observation wells (piezometers) and conduct a pumping test. The saturated thickness of the aquifer at OW-12 is about 40 feet so it is important to test pump the aquifer and determine the response of the aquifer to different pumping rates. The 6-inch pumping test well will ultimately be incorporated into the pump-out system. Because the available drawdowns in the vicinity of OW-12 are limited, a series of wells pumping at low rates would be necessary to intercept the plume. A total pumping rate of 100 gpm is calculated based on available ground water flow data. With wells at these locations, it would take approximately 10 years to remove two flushes of water from the known plume area. This system would effectively recover 95 percent of the presently known benzene in the ground water at the site. This estimate is based on plume maps from March 1984, which show only 5 percent of the benzene below the site boundary. It therefore assumes that OW-17 is the only known occurrence south of the site boundary and also that containment occurs in the vicinity of OW-12.

  A long-term, semiannual sampling and monitoring program for heavy metals and VOCs would be implemented. This program would include existing wells OW-9, OW-12, OW-13, OW-16, OW-17, OW-18, and OW-18A. In addition, three new monitoring wells, one near SD-55, one immediately upgradient of OW-12 and one immediately downgradient of the pumping wells, would be installed and monitored.

- Recovery downgradient of plume: Installation of a comprehensive downgradient recovery well system allows for virtually complete removal of the migrating contaminant plume of benzene. This estimate is based on identification and delineation of the leading edge of the plume and installation of a ground water recovery system downgradient of the leading edge. Therefore, this alternative recovery scheme ensures containment of the benzene plume by collecting all of the ground water containing benzene. However, this alternative would involve pumping a greater volume of water. Downgradient recovery of all ground water goes beyond what is necessary to mitigate the calculated off-site risk and would require the following four steps:

  - Definition of the leading edge of the plume and width of the bedrock valley

- A pump test to determine aquifer coefficients
- Installation of the recovery system
- Long term monitoring

These steps are explained in more detail in the following paragraphs.

Benzene has been detected in OW-17 at 402 ppb. However, wells OW-19 and OW-19A, 1500 feet downgradient of OW-17, do not contain benzene (see Figure 2-1). Soil samples from a test boring (TB-6) downgradient of OW-17 and due east of OW-19 and OW-19A also displayed no evidence of benzene. Therefore, the edge of the plume is somewhere between OW-17 and OW-19. To define the leading edge of the plume and width of the bedrock valley, additional drilling and sampling work is required. Drilling should start in the vicinity of OW-17, and continue downgradient until the southern most boundary of the plume is defined. At this point it will be necessary to continue drilling both east and west to define the width of the valley.

Once the leading edge of the plume has been defined, it will be necessary to conduct a pump test to determine the transmissivity (T) and storage coefficient (S) (specific yield) of the aquifer. To do this, it is proposed that an eight inch diameter pumping well be installed with four two-inch diameter piezometers suitably located to measure water levels during pumping of the aquifer. Prior to the actual pump test, a pre-pump test will be conducted to assure drawdown can be measured in the two inch piezometers at different pumping rates. After the pre-pump test is completed and a pumping rate established, the actual pump test can be performed. It is anticipated that a pumping rate of 150 gpm will be sufficient for this test. The test will run at least 24 hours, and possibly longer depending upon the effects of gravity drainage. After completion of the pump test, values calculated for T and S can be used to determine how many pumping wells will be necessary, their spacing, and the pumping rate. This information is required to design an intercept system that can effectively contain all groundwater downgradient of the site.

Based on measured and estimated aquifer characteristics, pumping at a rate of about 360 gpm will be sufficient to accomplish this task. This value was derived from the following formula:

$$Q = PIA$$

Where;

Q = gallons per day flowing through a given cross-section of the aquifer

P = Permeability (estimated from specific capacity tests at OW-19)

I = hydraulic gradient (measured from OW-16 - OW-19)

A = Cross sectional area (assuming valley is 1,000 feet wide and using saturated thickness at OW-19 of 66 feet)

$Q = (1,000\ gpd/ft^2) \times (0.004\ ft/ft) \times (66,000\ ft^2)$

Q = 260,000 gpd

Q = 180 gpm

Doubling this value to 360 gpm allows for a margin of safety. Based on a conservative groundwater flow rate of 1 ft/day, it will take about 10 years for one complete flush of the plume.

Assuming the bedrock valley is 1,000 feet wide at the location of the pumping wells, two to five 8-inch diameter pumping wells will be sufficient for the intercept system. These wells will be placed along a line from the eastern edge of Hall's Brook extending east, and spaced across the buried valley to intercept all potentially contaminated ground water flow. The total pumping rate of the wells is estimated at 360 gpm as explained above.

Existing wells both upgradient and downgradient of the pumping wells will be part of the monitoring program. A long-term or semiannual sampling and monitoring program for heavy metals and VOCs would be implemented. The recommended wells to be sampled are OW-20, OW-20A, OW-19, OW-19A, OW-17, OW-12, and OW-16. In addition, a new monitoring well near SD-55 and one or possibly two new monitoring wells immediately downgradient of the pumping wells should be installed and monitored. Monitoring will determine the effectiveness of the recovery system at containing the plume, and show changes in contaminant concentration and/or distribution within the plume with time.

2.3.2 Ground Water Treatment Alternatives

Ground water treatment alternatives included in the analysis are described in the following paragraphs.

Volatile Organic Compound (VOC) Air Stripping

Particular organic compounds exist that have a great affinity for dissolution from the aqueous phase into the vapor phase when the proper conditions prevail. These compounds are termed volatile organic compounds, and treatment technologies have been developed for their removal from ground waters. A technology that has been successful in several applications is VOC air stripping.

The treatment concept behind VOC stripping is to increase the water surface area available for contact with air to promote organic transfer from the aqueous to vapor phase. This is accomplished by cascading the contaminated water over a high surface area "packing" material within a column while simultaneously inducing an upward air draft. Benzene and toluene, two of the VOCs identified in minor plumes at the Woburn site, are examples of extremely strippable compounds. Based upon preliminary calculations and field studies performed with other water sources, the following conditions will reduce the benzene concentrations by greater than 99.93% for the following recovery systems:

Hot Spot Recovery

Total Pumping Rate:	50-75 gpm
Water Loading Rate:	32 gpm/sf
Column Diameter:	2 feet
Column Surface Area:	3.14 feet
Air to Water Ratio:	60 (air):1 (water)
Required Blower Capacity:	600 cfm
Total Packing Height Required:	40 feet

Recovery at Site Boundary

Total Pumping Rate:	110 gpm
Water Loading Rate:	32 gpm/sf
Column Diameter:	2 feet
Column Surface Area:	3.14 feet
Air to Water Ratio:	60 (air):1 (water)
Required Blower Capacity:	880 cfm
Total Packing Height Required:	40 feet

Recovery Downgradient of Plume

Total Pumping Rate:	400 gpm
Water Loading Rate:	32 gpm/sf
Column Diameter:	4 feet
Column Surface Area:	12.57 feet
Air to Water Ratio:	60 (air):1 (water)
Required Blower Capacity:	3,200 cfm
Total Packing Height Required:	40 feet

The air stripper emissions must comply with downwind ambient air and VOC standards. The Massachusetts DEQE VOC Standard for an installation such as the Woburn Site is 10,000 pounds/year. The Massachusetts DEQE suggested ambient air standard for benzene would take the OSHA limit and divide by 100 for additional safety. The OSHA limit for benzene is 10 ppm and 200 ppm for toluene. The suggested ambient air standard would, therefore, be 100 ppb for benzene and 2000 ppb for toluene.

However, the estimated background ambient air levels for the Woburn area is an average of 4 ppb for benzene and 8 ppb for toluene based on EPA air studies in Los Angeles, California; Phoenix, Arizona and Oakland, California[1].

The maximum yearly VOC (benzene and toluene) emissions and increases in downwind ambient air levels are as follows: (calculations in Appendix C)

Option	lb/year VOC	Increase in Benzene - ppb	Increase in Toluene - ppb
Pump Hot Spot	6,440	21.6 at 80 meters	20.3 at 80 meters
Pump at Site Boundary	950	0.4 at 170 meters	0.4 at 170 meters
Pump at Plume Boundary	250	0.1 at 210 meters	0.04 at 210 meters

Therefore, the yearly VOC emissions and maximum air emissions are in compliance with Massachusetts air standards.

Metal Precipitation

Metal precipitation is a treatment technology that has been successfully employed in industry and is included as a unit process that may be required as a pretreatment for effective volatile organics removal. The removal mechanism is based upon the relative solubility of metals at different pHs; specifically, as the pH increases, the metal solubility decreases. Therefore, pH adjustment with the addition of a small amount of flocculant aid (such as polymer) is an effective measure for removing metals. The degree of pH adjustment is dependent upon the particular chemical species to be removed.

The Sulfex™ process is a best available technology that consists of neutralization, hydroxide precipitation, hydroxide clarification, sulfide precipitation, sulfide clarification, polishing filtration, and sludge dewatering. It will generally reduce individual heavy metal levels to less than 100 ppb A schematic of the Sulfex process is provided on Figure 2-2.

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1. Singh, H. B., Salas, L. J., Smith, A., and Shigeishi, H., "Atmospheric Measurements of Selected Toxic Organic Chemicals, Halogenated Alkanes, Chlorinated Ethylenes, Chlorinated Organics, Aromatic Hydrocarbons and Secondary Organics," Interim Report Grant No. 805990, SRI Project 7774, SRI International, (April, 1980).

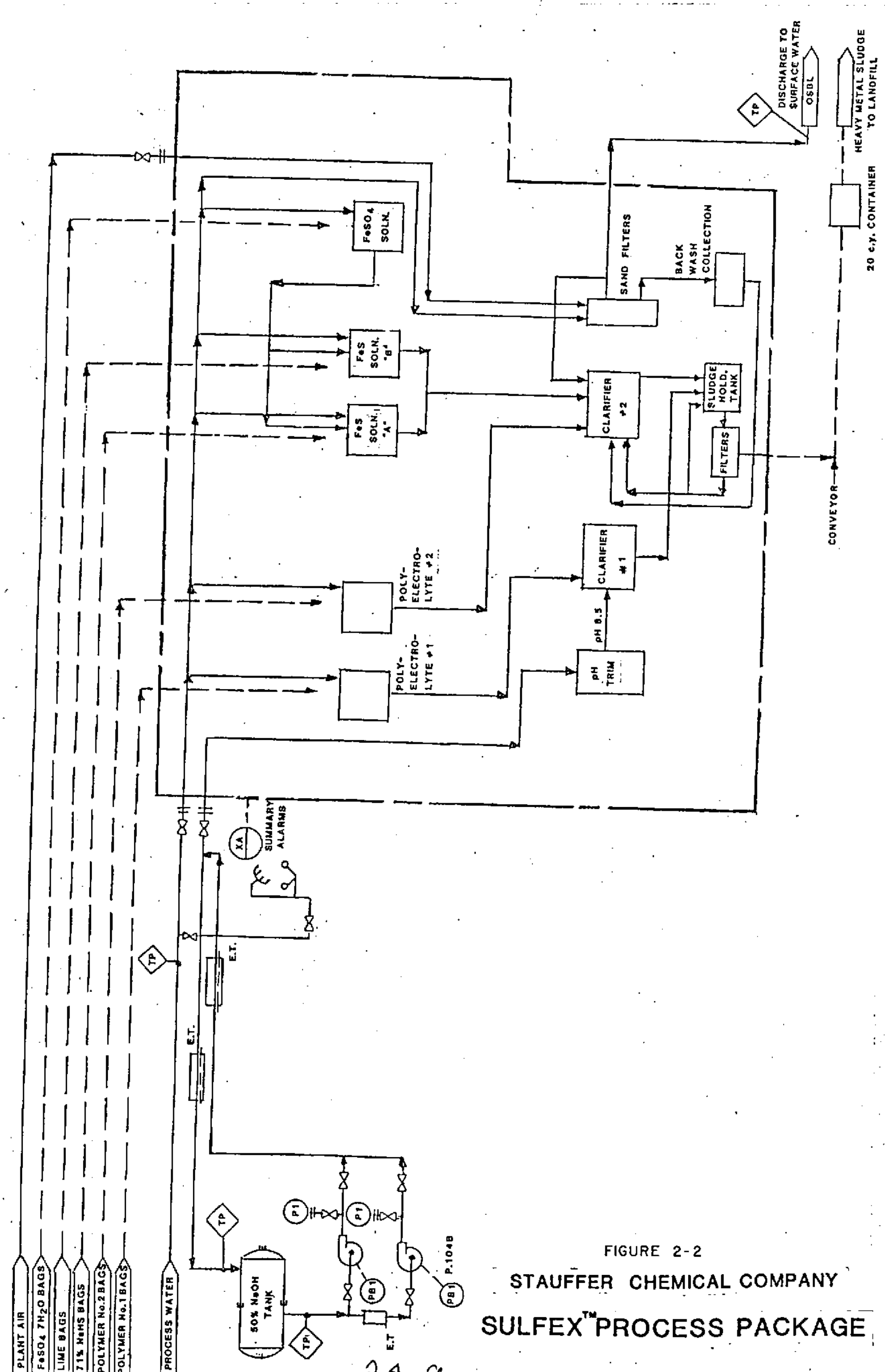


FIGURE 2-2

STAUFFER CHEMICAL COMPANY

SULFEX™ PROCESS PACKAGE

24-9

Knowing the expected flow rate of the heavy metal to be precipitated, an excess amount of sulfide is provided so that under normal conditions, all of the heavy metal can be converted to a sulfide. A quantity of iron is also provided so that all of the sulfide added can be precipitated as iron sulfide. Any excess iron in the system is precipitated as iron hydroxide by maintaining basic pH in the 8-9 range. Under these conditions, there is no significant discharge of soluble sulfide or iron with the water effluent and no detectable odor of H_2S.

In practice, the sulfide normally is added as a freshly made iron sulfide precipitate consisting of water, lime, sodium bisulfide (NaHS) and ferrous sulfate ($FeSO_4$). It is not necessary to match the addition rate of the iron sulfide exactly with the flow rate of heavy metals so long as some excess iron sulfide and iron hydroxide is normally removed with the sludge.

In addition to the iron sulfide, the process requires two reagent solutions:

A. Cationic polyelectrolyte for the hydroxide precipitation (Clarifier No. 1)

B. Cationic polyelectrolyte for the sulfide precipitation (Clarifier No. 2)

Oxidizing Agent Addition

Since it has been determined that the ground water from OW-16 contains odor-causing mercaptans at 15 ppm, it may be useful to provide odor control as a pretreatment step. The addition of a strong oxidizing agent such as hydrogen peroxide breaks down these compounds thus minimizing odor potential.

Granular Activated Carbon Adsorption

Typical carbon beds are totally enclosed vessels containing a bed of granular activated carbon similar in construction to countercurrent air stripping columns. The bed is held in place by perforated support plates at the bottom and often with a bed limiter plate at the top. Downflow type adsorbers typically are used since they are simpler to operate than upflow type beds.

The normal process provides two adsorber beds in series. When the device is started, contaminated water flows downward through the first bed, followed by downflow through the second bed. The quality of the effluent from the first bed is monitored and in time will allow the escape, or "breakthrough," of organic contaminants when the capacity of the first bed is reached. The beds are sized such that when the carbon is fresh, a single bed by itself adequately can remove the contaminants to the level desired.

When breakthrough from the first bed is observed, that bed is taken off-line and contaminated water flow is directed through the second bed only. The carbon in the first bed is removed for off-site regeneration typically using wet air oxidation to reclaim the carbon. The first bed is refilled with regenerated carbon brought on site by the contract carbon cleanup service. Flow continues to the second bed and, after the first bed is refilled, effluent from the second bed is piped downflow through the first bed. Total organic carbon can be used as an indicator parameter for continuous breakthrough monitoring. Because of operating costs however, carbon adsorption is not typically used in ground water treatment if biological methods (such as reactor units) are found to be suitable.

Suspended or Attached Growth Biological Reactors

Suspended or attached growth biological reactors provide removal of compounds that exert biochemical oxygen demand (BOD) in a receiving water body. Suspended growth systems are aerobic meaning oxygen is transferred into the reactor by either mechanical or diffusional means. The aerobic biological organisms utilize the oxygen in conjunction with the available food source (the BOD) to sustain life and reproduce. The substrate is converted into carbon dioxide, water and biomass. The biological organisms are transferred to a settling basin where a percentage are returned to the aeration basin and the remainder are disposed.

In attached growth systems, the wastewater is either diffused over media (trickling filters) or flowed through a basin in which plates rotate and place the attached organisms in contact with the substrate (rotating biological contactors). Air is introduced into a trickling filter through an updraft. In the rotating biological contactor, the organisms are put in contact with the air when the media plates are rotated out of solution.

A suspended growth system is operationally intensive since pumps are required to recycle biological floc to the aeration basin. In addition, sludge processing for excess biological floc is required. The systems are subject to upset and ususally are maintained at large facilities in which constant operator attention can be supplied.

Attached growth systems require little maintenance and usually are suitable for small installation. Although they cannot always achieve the same degree of treatment as suspended growth systems, they are stable, reliable, and resistant to shock loads.

2.3.3 Ground Water Discharge Alternatives

Treatment alternatives selected for remedial action depend upon recovery well location and the method of ultimate disposal. As such, remedial action alternatives range from treatment for odor and VOC removal, with ground water recharge, to treatment for odor, VOC, BOD, and metals removal, with discharge to surface water.

Pump, Treat, Recharge

In many applications it has been successful to cleanse contaminated ground water by treating and recharging treatment effluent into the aquifer upgradient of the collection wells when another discharge option is not available or feasible. For this application, ground water treatment may be required to achieve EPA drinking water standards prior to recharge.

Pump, Treat, Discharge to Surface Water

Treatment requirements for surface waters are dependent upon the classification of the waterway. The higher the classification, the more stringent the discharge criteria.

Regardless of the classification of the surface waters available around the Woburn site, it is likely that BOD removal and VOC stripping are required. In addition, negotiation for a State Pollution Discharge Elimination System (SPDES) permit would have to be initiated prior to, or coincident with treatment design.

Treatment Requirements for Discharge Alternatives

Treatment requirements for specific constituents vary depending upon the selected discharge alternative. Accordingly, discharge criteria were investigated for both alternatives outlined above. Tables 2-1, 2-2 and 2-3 outline discharge requirements for the ground water recharge and two surface water discharge alternatives, respectively.

TABLE 2-1

HOT SPOT RECOVERY
TREATMENT EFFICIENCIES FOR RECHARGE ON SITE[5]

Element Or Compound	Influent Concentration[1] (ppb)	Removal Efficiency	Effluent Concentration (ppb)	(SDWA) Safe Drinking Water Act Standards (ppb)
Antimony	5	N/A	5	N/A
Arsenic	10	N/A	10	50
Beryllium	7	N/A	7	N/A
Chromium	80	N/A	80	50
Copper	10	N/A	10	1,000[2]
Lead	25	N/A	25	50
Nickel	67	N/A	67	N/A
Silver	10	N/A	10	50
Zinc	104	N/A	104	5,000[2]
Benzene	9,300	99.93%	6.5	6.8[3]
Phenol	260	-	-	N/A
Toluene	10,300	99.93%	7.2	343[4]

Notes:

1. Assumed from average of OW-12, OW-16, OW-17 and SD-55.
2. Intended as a Federal guideline to protect the aesthetic qualities of water and hence referred to as a secondary regulation.
3. SNARL (Suggested No Adverse Response Level) for benzene at risk level of 1×10^{-5}.
4. SNARL (Suggested No Adverse Response Level) for toluene is longer term.
5. Treatment System: Odor Control/Air Stripping

TABLE 2-2

INTERCEPTION AT SITE BOUNDARY
TREATMENT EFFICIENCIES FOR DISCHARGE TO SURFACE WATER[2]

Element or Compound	Influent Concentration[1] (ppb)	Removal Efficiency	Estimated[4] In-Stream Concentration (ppb)	Water Quality Criteria Documents — Fresh Water Aquatic Life: Acute (ppb)	Water Quality Criteria Documents — Fresh Water Aquatic Life: Chronic (ppb)	Human Health[5] Criteria (ppb)
Antimony	5	N/A	-	9,000	1,600	-
Arsenic	10	N/A	3	440	-	50[5]
Beryllium	7	N/A	2	130	5.3	3.7
Chromium	80	N/A	27	9,900	44	170,000
Copper	10	N/A	3	43	-	1,000
Lead	25	N/A	8	20	-	50
Nickel	67	N/A	22	160	-	13.4
Silver	10	N/A	3	13	-	50
Zinc	104	N/A	33	47	-	5,000[5]
Benzene	9,300	99.93%	2.2	5,300	-	6.8[6]
Phenol	260	95%	13	10,200	2,560	3,500
Toluene	10,300	99.93%	2.4	17,500	-	14,300
BOD	300 ppm	95%	15 ppm	-	-	-

Notes:

1. Assumed from average of OW-12, OW-16, OW-17 and SD-55.
2. Treatment System: Biological/Air Stripping.
3. A dash (-) indicates that a level has not yet been determined. N/A indicates that removal is not applicable at the influent concentrations listed to maintain compliance with currently existing regulations.
4. Estimated in-stream concentrations are based on dilution factors of approximately 33 percent for the receiving water low flow of 300,000 gpd and estimated effluent of 150,000 gpd.
5. Human Health Critiera are comprised of either chronic human health concentrations (from Water Quality Critiera Documents) or Safe Drinking Water Act (SDWA) standards. In cases where the SDWA was used, a footnote (5) appears.
6. SNARL (Suggested No Adverse Response Level) for benzene at risk level of 1 x 10^{-5}.

TABLE 2-3

INTERCEPTION DOWNGRADIENT OF PLUME
TREATMENT EFFICIENCIES FOR DISCHARGE TO SURFACE WATER[2]

Element or Compound	Influent Concentration[1] (ppb)	Removal Efficiency	Estimated[4] In-Stream Concentration (ppb)	Water Quality Criteria Documents Fresh Water Aquatic Life Acute (ppb)	Water Quality Criteria Documents Fresh Water Aquatic Life Chronic (ppb)	Human Health[5] Criteria (ppb)
Antimony	ND	N/A	-	9,000	1,600	-
Arsenic	7	N/A	3.5	440	-	50[5]
Beryllium	ND	N/A	ND	130	5.3	3.7
Chromium	ND	N/A	ND	9,900	44	170,000
Copper	50	N/A	25	43	-	1,000
Lead	15	N/A	13	20	-	50[5]
Nickel	10	N/A	10	160	-	13.4
Silver	ND	N/A	ND	13	-	50
Zinc	10,670	99.1%	48	47	-	5,000[5]
Benzene	115	99.93%	<0.08	5,300	-	6.8[6]
Phenol	-	N/A	-	10,200	2,560	3,500
Toluene	40	99.93%	<0.03	17,500	-	14,300
BOD	-	-	-	-	-	-

Notes:

1. Assumed from average of OW-17, OW-18, OW-18a, OW-19, OW-19a
2. Treatment System: Biological/Air Stripping/Heavy Metal Removal.
3. A dash (-) indicates that a level has not yet been determined. N/A indicates that removal is not applicable at the influent concentrations to maintain compliance with currently existing regulations.
4. Estimated in-stream concentrations are based on dilution factor of 50 percent for the receiving water low flow of 600,000 gpd at the confluence and estimated effluent of 600,000 gpd from downgradient of plume recovery.
5. Human Health Critiera are comprised of either chronic human health concentrations (from Water Quality Critiera Documents) or Safe Drinking Water Act (SDWA) standards. In cases where the SDWA was used, a footnote appears.
6. SNARL (Suggested No Adverse Response Level) for benzene at risk level 1×10^{-5}.

2.4 Detailed Analysis of Ground Water Remedial Actions

2.4.1 Ground Water Interception/Recovery

Ground water management at the Woburn site includes three discrete processes: interception/recovery, treatment and discharge. The functional analysis for the ground water interception/recovery alternatives listed below is presented in Table 2-4.

- Downgradient of plume recovery of ground water.
- Downgradient of site recovery of ground water.
- On-site hot spot recovery.

The three interception/recovery locations are illustrated on Figure 2-3.

On-site hot spot recovery will be retained as a viable alternative because:

- Hot spot pump out systems implemented on-site to collect the concentrated slugs of contaminants would enhance recovery due to the proximity of the wells to the apparent benzene source.

- Pumping duration would be shorter due to collection of relatively undiluted contaminant plume.

- System costs and implementation time would be reduced to a minimum compared to either downgradient of site or downgradient of plume recovery of ground water.

One major disadvantage with this recovery alternative, however, is the difficulty of defining a hot spot. This may lead to increased migration of the benzene plume thereby making it slightly less reliable than either downgradient recovery alternative.

Downgradient of site recovery of ground water will be retained due to the potential of the alternative to collect the majority of the presently known concentrations of the benzene in the contaminated ground water plume. Collecting about 95 percent of the migrating ground water plume will minimize the potential risk to the downgradient receptor population. This option will require a much greater implementation time and a much more complex treatment system than the hot spot option.

Downgradient of plume recovery of ground water will be retained because of the ability of the alternative to prevent any potential adverse impact on the downgradient aquifer and population. Complete removal of the ground water

TABLE 2-4

FUNCTIONAL ANALYSIS MATRIX -- FUNCTIONAL AREA: GROUND WATER INTERCEPTION/RECOVERY

Evaluation Criteria	Weighting Factor	On-Site Hot Spot Recovery		Downgradient of Site Recovery of Ground Water		Downgradient of Plume Recovery of Ground Water	
		Rating	Comment	Rating	Comment	Rating	Comment
1. Reliability	1.1	4	Difficult to define hot spot	5	Would collect the majority of presently known concentrations of benzene	5	Would ensure that no benzene migrates downgradient
2. Constructibility	0.6	5	Easiest to install due to minimum number of wells installed at shallower depth	4	Fewer wells than full downgradient recovery	2	Up to 5 recovery wells to withdraw the entire plume
3. Implementation Time Frame	0.5	5	Pumping duration shorter due to relatively undiluted contaminant plume	3	May require as long as 11 years due to variable flowrates	2	Long period to set up, operate and complete recovery of migrating benzene
4. Environmental Effectiveness	2.0	3	Will reduce the potential risk to the downgradient receptor population	4	Will minimize the potential risk to the downgradient receptor population	5	Will nullify the potential risk to the downgradient receptor population
Total		15.9		17.4		18.9	

Note: Ratings range from 1 (poor) to 5 (excellent).

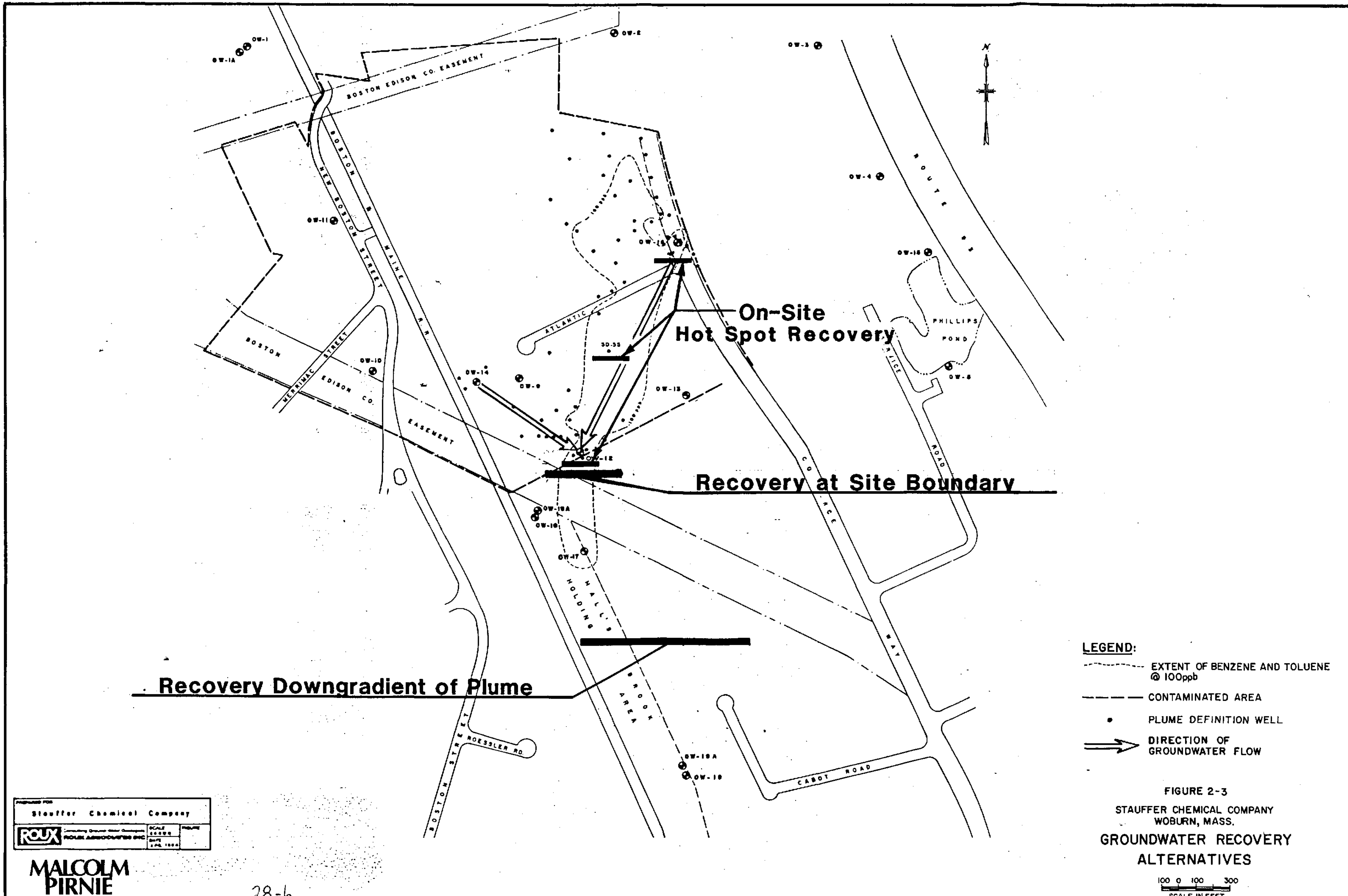


FIGURE 2-3
STAUFFER CHEMICAL COMPANY
WOBURN, MASS.
GROUNDWATER RECOVERY ALTERNATIVES

28-b

plume would ensure that virtually all benzene is contained. Downgradient of plume recovery would require the same valley boundary determination as downgradient of site recovery and up to five recovery wells to withdraw virtually the entire plume. The large volume of ground water involved would result in a long implementation period to set up the entire recovery system, bring it on-line, and recover virtually all of the migrating benzene.

2.4.2 Ground Water Treatment

Table 2-5 presents the functional analysis for all four viable groundwater treatment schemes listed below:

- Air stripping
- Odor control and air stripping
- Biological treatment and air stripping
- Biological treatment, air stripping and precipitation/flocculation

Air stripping alone will be retained as a viable alternative due to the following:

- Air stripping does not require intensive pretreatment to maintain reliable performance.

- Air stripping may meet all applicable environmental regulations.

- Air stripping requires minimum construction and implementation time.

The combination of odor control and air stripping will be retained as a viable remedial method due to the following:

- The method does not require intensive pretreatment to maintain reliable performance.

- Odor control by hydrogen peroxide addition requires slightly more process equipment than air stripping alone so that construction requirements and associated implementation are low, within two to three months.

- Odor control is environmentally effective in that it will minimize degradation of ambient air quality while reducing the organic content of the waste stream for subsequent treatment.

- However, the method may exhibit a lack of ability to remove organic contaminants that are not amenable to air stripping such as phthalates and phenols.

- There may be sufficient mercaptans in downgradient wells which require odor removal.

TABLE 2-5

FUNCTIONAL ANALYSIS MATRIX -- FUNCTIONAL AREA: GROUND WATER TREATMENT

Evaluation Criteria	Weighting Factor	Air Stripping		Biological Treatment, Air Stripping		Odor Control, Air Stripping		Biological Treatment, Air Stripping, Precipitation/Flocculation	
		Rating	Comment	Rating	Comment	Rating	Comment	Rating	Comment
1. Reliability	1.1	4	Impacted by alkalinity and iron	3	Biological treatment requires additional operator attention	4	Impacted by alkalinity and iron	2	Dependent on continual process monitoring of mixing speed, chemical addition rate and overflow rate
2. Constructibility	0.6	5	Easily constructed as package system	3	Biological system requires additional unit, although package system is available	5	Easily constructed as package system	2	Construction involves mixing, flocculation, sedimentation, sludge withdrawal and storage areas
3. Implementation Time Frame	0.5	4	Can be on-line within 2 or 3 months	3	Increased number of process components increases implementation time frame	4	Can be on-line within 2 or 3 months	3	Implementation time frame is longer due to the complexity of the process and the number of process components
4. Environmental Effectiveness	2.0	4	Should alleviate ground water problems if clean background air is available and no other organic compounds other than benzene and toluene identified	4	Biological treatment required only for water discharge	3	Odor control with hydrogen peroxide would reduce organic content of waste stream making subsequent stripping easier. Phenol removal difficult	4	Provides most thorough treatment, but sludge dewatering and disposal practices must be managed properly to prevent contaminant release
Total		17.4		14.4		15.4		12.9	

Note: Ratings range from 1 (poor) to 5 (excellent).

A schematic of this treatment scheme is illustrated on Figure 2-4.

Biological treatment and air stripping will be retained as a viable alternative as a result of the following:

- The method is an assembly of package plants [assuming a rotating biological contactor (RBC) for BOD removal] which can be coordinated effectively for reliable treatment.

- The method is not operationally intensive, although some degree of operator attention will be required for the RBC.

- The system can reliably achieve the required removals, although a 95 percent efficiency in the RBC will somewhat be dependent upon the variation and extent of BOD loading.

A schematic of this treatment system is illustrated on Figure 2-5.

Odor control, precipitation, flocculation/sedimentation, biological treatment followed by air stripping was ranked below other alternatives as a result of the following:

- Reliability of the operation is dependent on continual process monitoring of mixing speed, chemical addition rate and overflow rate. The delicate process control results in lower reliability than air stripping.

- Constructibility is more involved due to required pH and alkalinity adjustment, equipment, mixing, flocculation and sedimentation stages in the process. The process also requires sludge withdrawal, handling, and storage facilities, and larger chemical storage facilities than for air stripping.

A schematic of this treatment system is illustrated on Figure 2-6.

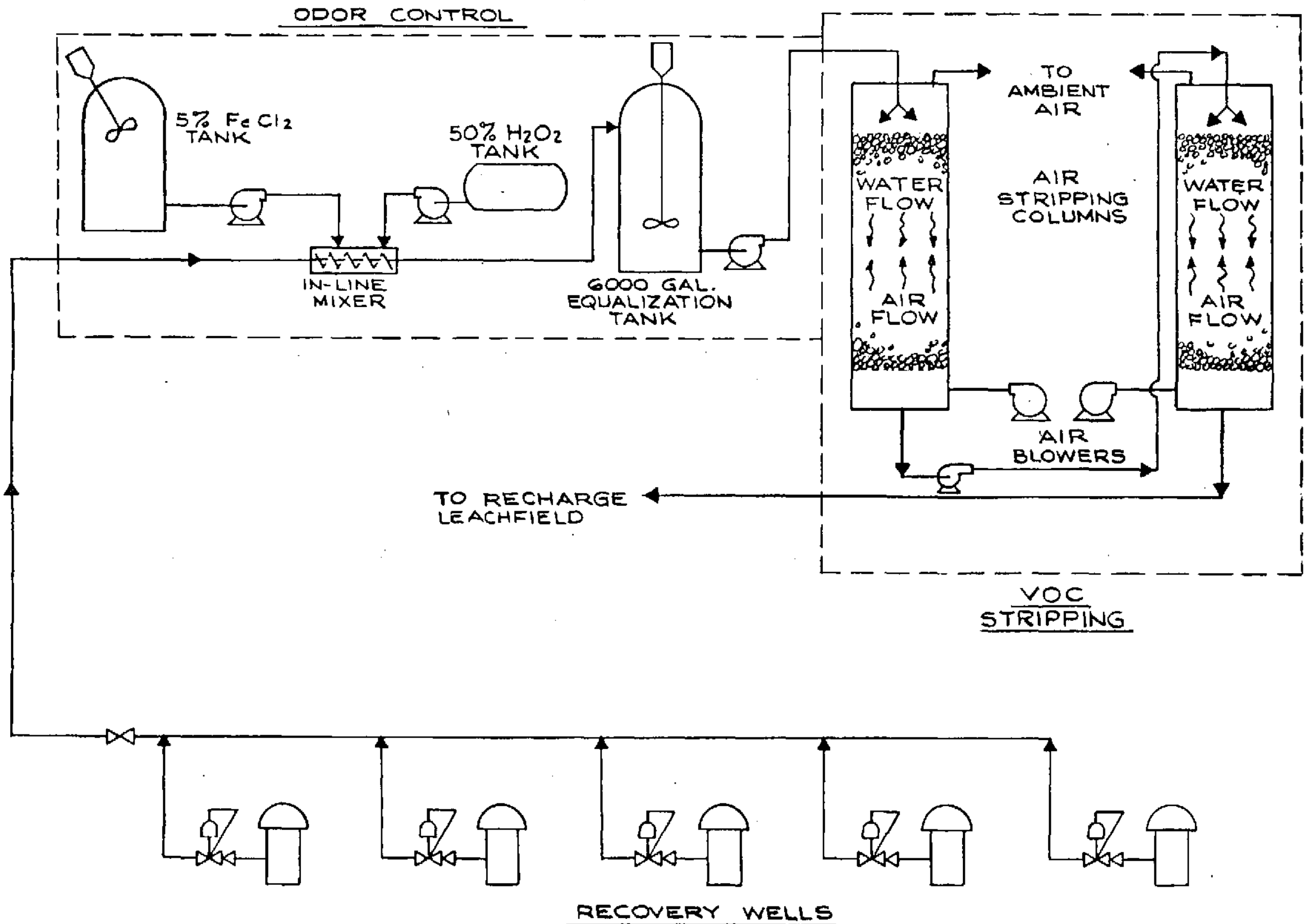
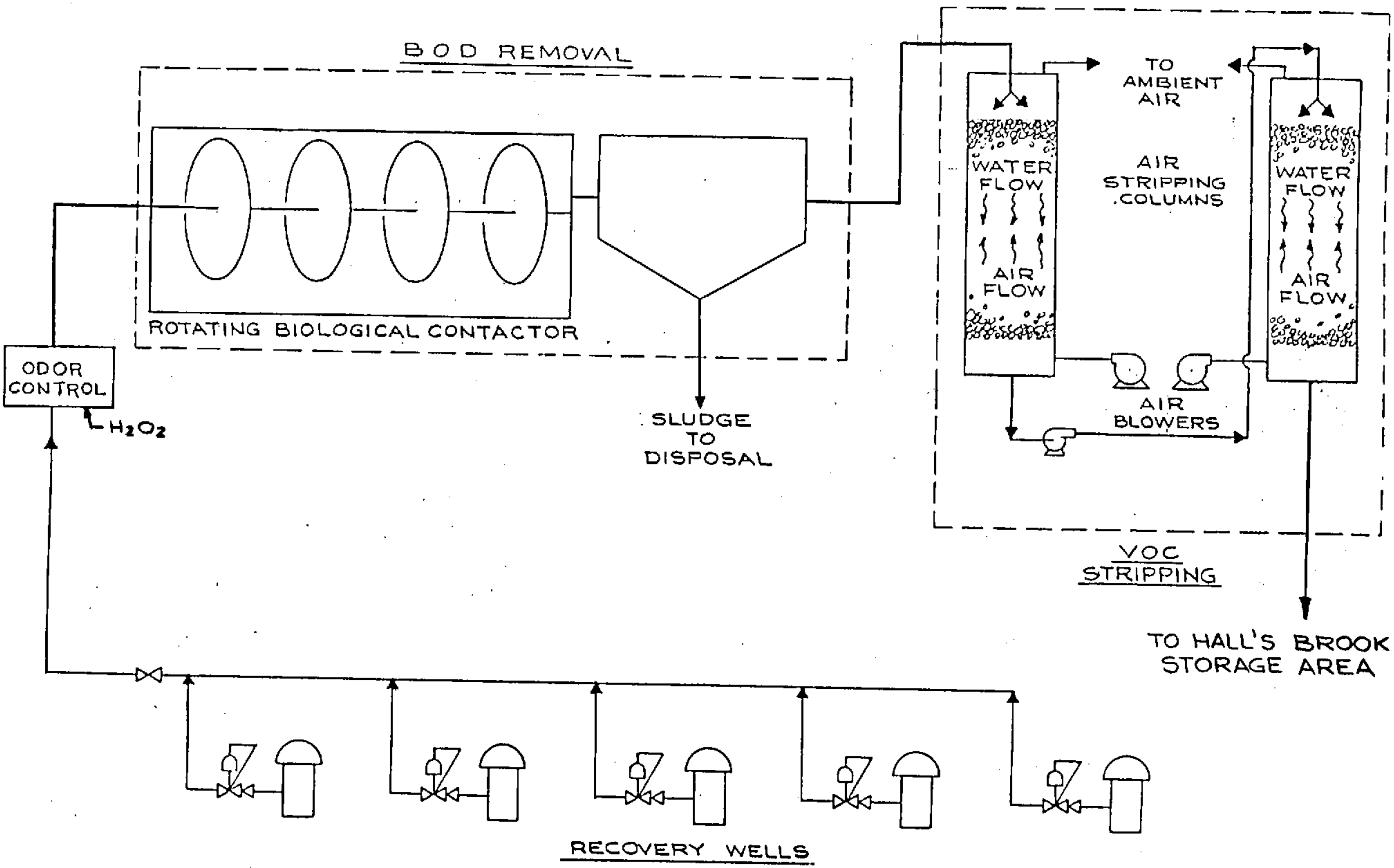


FIGURE 2-4

STAUFFER CHEMICAL COMPANY
WOBURN, MASS.

GROUND WATER TREATMENT
FLOW SCHEMATIC FOR OPTION I
(HOT SPOT RECOVERY)

30-9



30-6

FIGURE 2-5
STAUFFER CHEMICAL COMPANY
WOBURN, MASS.
GROUNDWATER TREATMENT
FLOW SCHEMATIC FOR OPTION 2
(DOWNGRADIENT OF SITE RECOVERY)

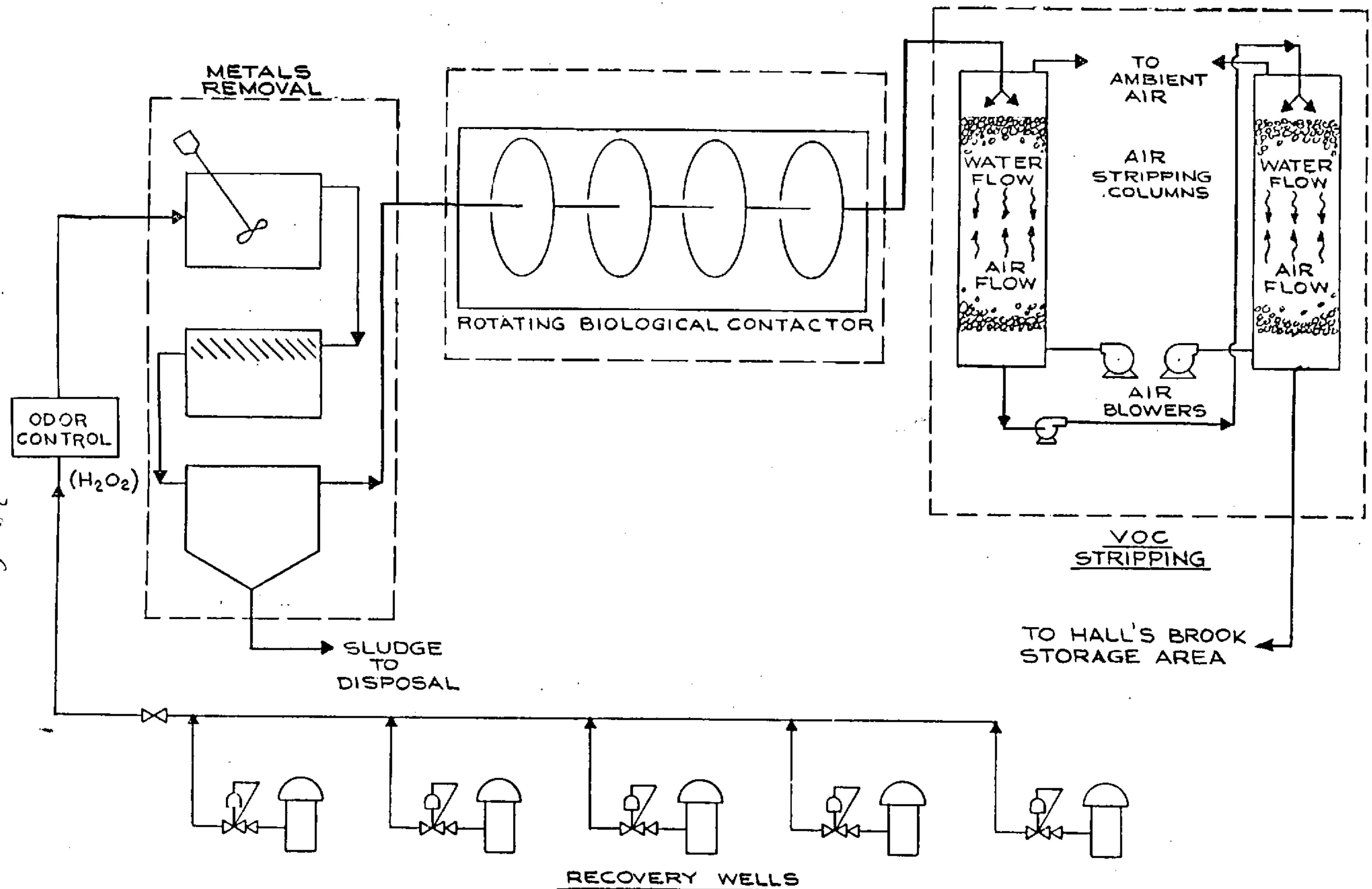


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FIGURE 2-6
STAUFFER CHEMICAL COMPANY
WOBURN, MASS.

GROUNDWATER TREATMENT
FLOW SCHEMATIC FOR OPTION 2 OR OPTION 3
(DOWNGRADIENT OF PLUME RECOVERY)
WITH METALS REMOVAL

2.4.3 Discharge of Collected Ground Water

The third component included in ground water management is discharge of the recovered ground water, either with or without prior treatment. There are three feasible discharge options for the Woburn site:

- Recharge to the aquifer upgradient of the pumping wells
- Recharge to the aquifer downgradient of the pumping wells
- Discharge to surface water

Table 2-6 summarizes the functional analysis of the discharge alternatives. Advantages and disadvantages for each of the three discharge alternatives are summarized in Table 2-7.

TABLE 2-6

FUNCTIONAL ANALYSIS MATRIX -- FUNCTIONAL AREA: GROUND WATER DISCHARGE

Evaluation Criteria	Weighting Factor	Pump, Treat, Recharge		Pump, Treat, Discharge to Surface Water	
		Rating	Comment	Rating	Comment
1. Reliability	1.1	1	Reliability of the process varies with the site subsurface conditions to be determined. May not be feasible without flooding and direct discharge to surface water	3	Potential for process upsets and degradation of receiving waters requires more complicated treatment
2. Constructibility	0.6	2	May require deep injection wells to prevent flooding of developed areas	3	Involves less complex construction than either recharge option
3. Implementation Time Frame	0.5	3	Extensive due to required SDWA/UIC permit, subsurface investigation and construction of recharge system	3	Implementation time less than the recharge options
4. Environmental Effectiveness	2.0	4	Recharged water would meet DWS	4	Requires treatment to a level that ensures maintenance of surface water quality standards
Total		11.8		14.6	

Note: Ratings range from 1 (poor) to 5 (excellent).

TABLE 2-7

ADVANTAGES AND DISADVANTAGES FOR
THE THREE DISCHARGE ALTERNATIVES

Discharge to Aquifer Upgradient of Pumping Wells

Advantages	Disadvantages
Allows for containment and recycle of treated water - thus allows an extra margin of safety because of containment of recycled water	Can only discharge small volume (may work for hot spot pump out only)

Discharge to Aquifer Downgradient of Pumping Wells

Advantages	Disadvantages
Maintains the same volume of water in the aquifer	May cause flooding problems in developed area
Provides additional filtering (in aquifer) of treated water	Uses land area that could be put to other use
	May require extensive and costly maintenance to keep in operation

Discharge to Surface Water

Advantages	Disadvantages
Known and proven technology assures success	May require additional or more complex treatment
Rapid clean up or dilution of an upset	Slight reduction in the ground water resource
Less exposure potential in drinking water	
No clogging or flooding problems	
No flow limit	

2.5 Cost Effective Ranking for Ground Water Remedial Alternatives

A comparison of the costs is provided as Table 2-8 for the selected ground water recovery, treatment and discharge alternatives. The detailed cost estimates are provided in the attached Appendix I for each ground water remedial alternative described below:

1. Hot spot recovery, treatment, recharge on-site (Option 1)

2. Downgradient of site recovery, treatment, discharge to surface water (Option 2)

3. Downgradient of plume recovery, treatment, discharge to surface water (Option 3)

Capital costs for each selected alternative were based upon 1985 costs, vendor quotations, and were adjusted to incorporate the Boston area price index. Operation and maintenance costs were analyzed on a present worth basis incorporating a 12 percent interest rate, 6 percent inflation rate and 15-year design life.

The cost comparison of selected alternatives from the ground water recovery, treatment and discharge functional analyses as summarized in Table 2-8 results in the following cost-effectiveness ranking for the selected alternatives.

The recommended cost effective ranking for ground water recovery and discharge is summarized as follows:

1. Downgradient pumping at the site boundary, odor treatment, with H_2O_2, VOC stripping, BOD removal and discharge to Halls Brook Storage area.

2. Downgradient pumping at the plume boundary, odor treatment with H_2O_2, VOC stripping, BOD removal, Zinc removal with Sulfex^{TM} heavy metal treatment system and discharge to Halls Brook Storage area.

3. Hot Spot pumping on site, odor treatment with H_2O_2, VOC stripping and recharge to ground water.

Downgradient pumping at the site boundary was ranked highest because it would achieve 95 percent benzene removal without the expensive and technically complicated Zinc Sulfex^{TM} precipitation required for downgradient of plume pumping. Both downgradient pumping options would meet EPA's Suggested No

TABLE 2-8

COST COMPARISON OF SELECTED ALTERNATIVES FROM GROUND WATER FUNCTIONAL ANALYSIS RESULTS

Remedial Alternative/Description	Capital Cost	O&M Cost	Total Implementation Cost	Recommended Ranking	Ranking Rationale
I. Hot spot recovery, treatment with odor control, air stripping, recharge on-site	\$0.8 M	\$0.14 (2)	\$0.94M	3	- Least stringent treatment required, roughly one-fourth the cost of highest ranked alternative
II. Downgradient of site, recovery, treatment with odor control, air stripping, discharge to surface water	\$1.25 M	\$2.4 M (3)	\$3.65 M	1	- Stringent treatment required to meet surface water criteria.
III. Downgradient of plume recovery, treatment with odor control, RBC, air stripping, metals removal discharge to surface water	\$4.5 M	\$6.5 M (3)	\$11.0 M	2	- More than triple the cost of highest ranked alternative without significant benefit

Notes:

1. See Appendix for detailed Cost Estimates.
2. 6-Month O&M period for Alternative I
3. 15-Year O&M period for Alternatives II and III.

Adverse Response Level (SNARL) of 6.7 ppb benzene at municipal wells G & H. Downgradient of plume pumping should achieve nondetectable levels of benzene at G & H wells, while Roux Associates ground water modeling study (Appendix B) showed 2 ppb benzene for downgradient of site pumping. However, the removal of the last 1/3 of the SNARL benzene limit would cost an estimated extra $7,350,000 and decrease reliability because of the need for Zinc removal from downgradient of plume wells.

Only two potential ground water discharge options (i.e., recharge to the ground and surface discharge) were suitable, since the MDC refused to accept ground water. However, Roux Associates advised that because of local hydrogeologic conditions ground water recharge is only practical for small quantities, and that downgradient of site pumping and downgradient of plume pumping exceed the allowable recharge amounts. Therefore, for both downgradient pumping options, the water would have to be treated to meet surface water standards and discharged to the Halls Brook storage area.

The anticipated downgradient of site ground water recover would require odor treatment, VOC stripping and BOD removal for surface water discharge (Table 2-2). The anticipated downgradient of plume ground water recovery would require VOC stripping, odor treatment, BOD removal and Zinc removal (Table 2-3). The downgradient of site wells do not exceed "Surface Water Quality Criteria" for heavy metals. However, the downgradient of plume wells contain an estimated 10,700 ppb zinc which exceed the "Surface Water Quality Criteria" for fresh water aquatic life of 47 ppb. The only proven technology to meet the surface water zince standard is the Sulfex two step precipiration process which should reduce zinc below 100 ppb. Single step hydroxide precipitation is only expected to reduce the zinc to between 1,000 and 2,000 ppb by itself. The capital and O/M cost for the Sulfex heavy metal treatment system is estimated to cost $7,350,000 for the downgradient of plume ground water recovery. It is also complicated and thus decreases reliability.

The hot spot pumping option is not considered acceptable since Roux Associates advised that it will not reduce the wells G & H benzene level below the 6.7 ppb SNARL level.

It should be noted that these treatment requirements are based upon extremely limited treatability data. Although continual sampling has identified compounds to be removed and their related concentrations in the ground water, the manner in which these compounds can be effectively and reliably removed is somewhat uncertain. Two analyses of ground water grab samples have indicated that extremely high alkalinities may be present. If this preliminary finding is correct, the effect of this on treatment processes, particularly odor control and solids removal, is uncertain. Pilot treatability studies are therefore mandatory to ensure that the proposed design will provide the anticipated effective and reliable treatment.

3.0 Odor Control Remedial Program

Introduction

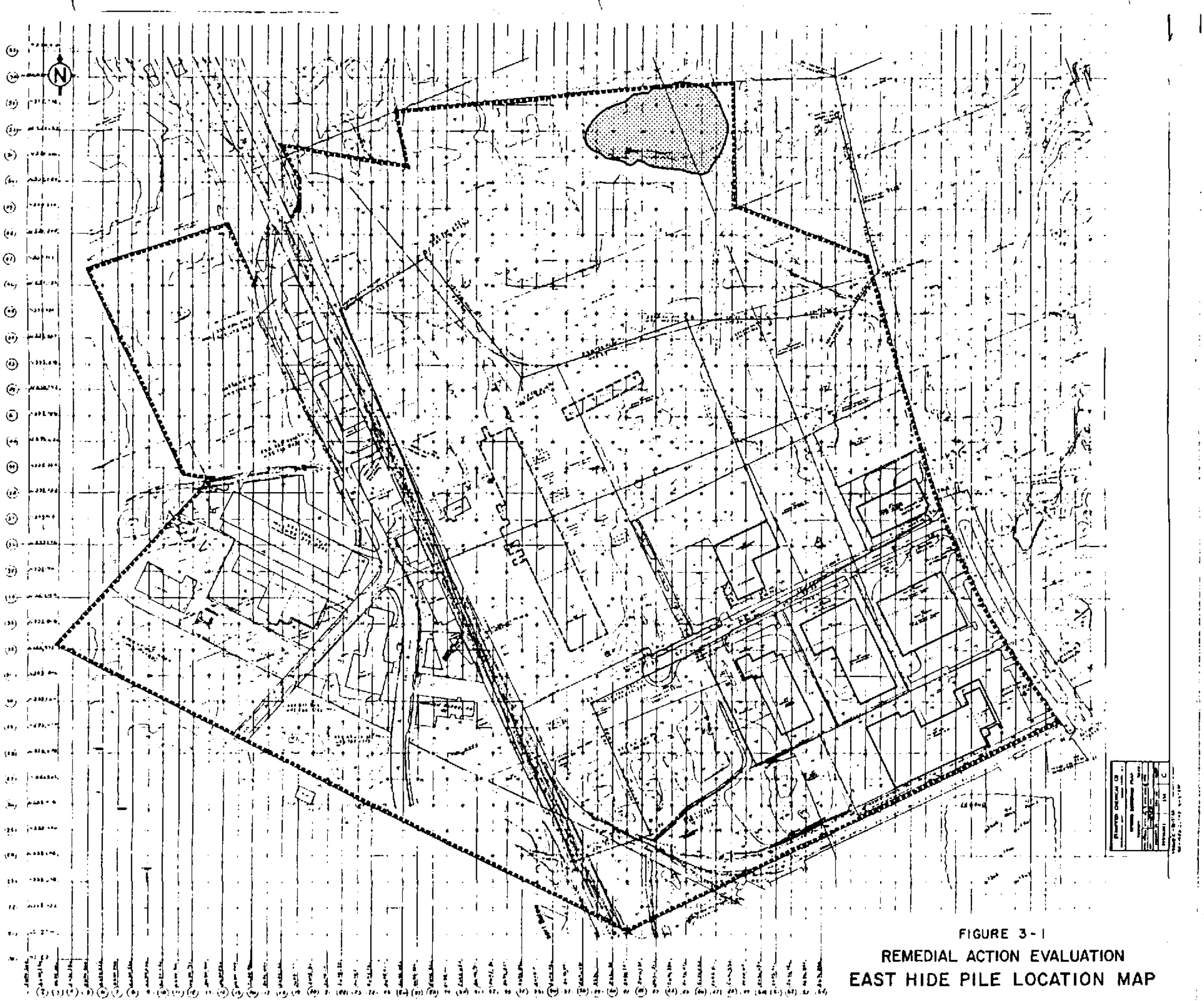
Four primary hide piles were identified at the project site. These piles were throughly investigated and findings were reported in the Phase II Report. However, only the East Hide Pile was found to be a significant source of odor. This section will address East Hide Pile odor control as well as the inter-related issues of leachate infiltration and surface water controls. Section 4.0 will address the contaminated soil problems associated with the West, East-Central, and South hide piles.

Summary of Existing Information

The maximum measured East Hide Pile emission rate during the Phase II investigation was 1.8 ACFM. However, based on theoretical estimates and experience at other landfills, the actual average emission rate could be 250 percent greater or 5 ACFM. (Remedial Investiation Report pg. IV-14.) It will be assumed, for comparison of remedial action alternatives, that the average East Hide Pile emission rate is 2-5 ACFM.

The Phase I and II site investigations identified H_2S as the primary odor constituent and the East Hide Pile as the source os site H_2S (Figure 3-1) based on the following:

- November 1981 A.D. Little Off Site Survey
- September-October 1983 A.D. Little Site Evaluation
- Stauffer's Phase I bore hole gas analysis which found nondetectable (N.D.) to 5 percent H_2S compared to N.D. to 0.05 percent total other odorous gases
- Stauffer's Phase II bore hole gas analysis which found N.D. to 2 percent H_2 S compared to N.D. to 0.04 percent total other odorous gases
- The Phase I East Hide Pile bore hole gas analysis averaged 2.7 percent H_2S and 220 ppm other odorous gases. The remaining site bore holes contined N.D. amounts of H_2S or other odorous gases
- The Phase II East Hide Pile bore hole analysis averaged 1.4 percent compared to a maximum of 0.6 percent elsewhere in the site
- The measured Phase II East Hide Pile bore hole gas emissions were 1.82 CFM from the East Hide Pile, 0.65 CFM from the West Hide Pile and nondetectable from the remainder of the site. However, the 0.65 CFM from the West Hide Pile only averaged 55 ppm H_2S



35-9

FIGURE 3-1
REMEDIAL ACTION EVALUATION
EAST HIDE PILE LOCATION MAP

3.1 Odor Control Remedial Technologies

A detailed literature search and review of similar past experience was conducted to identify generic remedial approaches for odor control. In any feasible gas control remedial action, it was assumed that regrading to a 3:1 slope, capping, covering, and establishing vegetation would be necessary. This assumption is based on the mutual reduction of both rainfall infiltration and odor release. Generic approaches which are of potential value for remediation of the odor problem at the Woburn site include:

3.1.1 Gas Collection

- Active gas collection
- Passive gas collection
- Pipe vents
- Trench vents

3.1.2 Gas Control

- Tall stack dispersion
- Gas barriers

3.1.3 Gas Treatment Systems

- Ion exchange
- Vapor phase adsorption
- Chemical oxidation
- Thermal oxidation
- Stabilization

3.2 Identification of Woburn Site Specific Remedial Action Alternatives

Based upon the currently available technologies, an extensive list of site specific remedial alternatives were developed for gas collection, control and treatment.

The alternatives presented in this section will be screened in Section 3.3 to evaluate their potential mitigation of negative air impacts at the Woburn site.

3.2.1 Gas Collection

- Construct a passive gas collection system
- Construct an active gas collection system

3.2.2 Gas Control

- Installation of a tall stack

- Construction of a cap system consisting of either an impermeable membrane liner, clays, soil admixtures, asphalts, or urea-formaldehyde materials

3.2.3 Gas Treatment

- Vapor Phase Adsorption

  - Carbon adsorption treatment system
  - Ion exchange resin treatment system

- Thermal Oxidation

  - Installation of flare or afterburner

- Stabilization

  - A pH adjustment using sodium bicarbonate or lime to expedite the transition of the East hide pile from an active to passive emission source

- Chemical Oxidation

  - Addition of hydrogen peroxide or ozone to reduce odor emission

3.3 Screening Methodology

Based on the specific alternatives developed, two stages of screening are conducted. First, alternatives which are not feasible are omitted from further consideration. Those alternatives omitted and the associated omission rationale are shown below:

AIR EMISSIONS METHODS OMITTED FROM FURTHER CONSIDERATION

Remedial Method	Omission Rationale
Gas Control	
1. Urea-Formaldehyde barriers	Feasibility and Reliability: Effective permeability of foam can be unreliable due to frequently encountered installation problems.
2. Tall Stack Dispersion	Feasibility and Reliability: Under current policy, tall stack dispersion is not acceptable to Massachusetts DEQE for odor control.
Gas Treatment	
1. Chemical Oxidation	Environmental Effectiveness: Chemical oxidation using ozone or hydrogen peroxide has potential to generate hazardous waste.
2. Ion Exchange	Feasibility and Reliability: Not as reliable as more commonly used carbon adsorption.
3. Excavate and Remove East Hide Pile	Cost, Negative Environmental Impact Potential: Cost would be an order of magnitude greater than other feasible alternatives. In addition, tremendous odor generation would result from unearthing decomposing waste material.
4. Stabilization	Environmental Effectiveness: Stabilization using lime or sodium biocarbonate has not been proven effective for reducing emission rates in landfills.

In the second screening stage, the retained alternatives described below are evaluated in more detail:

AIR EMISSION METHODS RETAINED FOR FURTHER EVALUATION

Remedial Method	Retention Rationale
Gas Collection	
1. Pipe Vents, Trench Vents and gas collection systems	Environmental Effectiveness: Pipe vents, trench vents and gas collection systems have been proven as an effective means of collecting gaseous emissions in a sediment/soil environment for subsequent treatment and discharge.
Gas Control	
1. Gas Barriers consisting of synthetic liner, clay, soil admixture or asphalt	Environmental Effectiveness, Feasibility and Reliability: Installation of liners or covers to function as gas barriers has been proven as an effective strategy to limit gas emission from soil and waste deposit environments.
Gas Treatment	
1. Carbon Adsorption	Environmental Effectiveness: Carbon adsorption will remove odor causing components present in the gaseous emissions
2. Thermal Oxidation	Environmental Effectiveness: Thermal oxidation will remove odor causing components present in the the emissions.

Description of Retained Remedial Alternatives

3.3.1 Gas Collection - Currently, the East Hide Pile behaves similar to a poorly designed passive gas release system. As the barometric pressure drops below internal pressure, gaseous release to the atmosphere results. The release occurs randomly through the most permeable portions of the pile and through fissures resulting from unstable sideslopes. Therefore, design strategies should address mitigating gas release and reducing gas production. Cover requirements and collection systems should be tailored to achieve these objectives. A useful design strategy to meet these requirements is to collect gases to a centralized location via a gas collection medium where treatment alternatives such as thermal oxidation or carbon adsorption can be employed. The surface immediately above the collecton medium is usually capped with clay and/or a synthetic membrane to prevent upward migration of gas and rainwater infiltration.

To remedy the H_2S/combustible gas generation problem at the Woburn site, pipe venting is another feasible means of gas collection. Pipe vents consist of vertical or lateral perforated pipes that extend from the material to be vented to treatment systems such as carbon adsorption or thermal oxidation. The pipe is usually about 4 to 8 inches in diameter, and is surrounded by a gas collection medium consisting of coarse pea gravel.

Trench venting utilizes an excavated ditch filled with crushed rock or pea gravel to convey the gaseous emissions to a centralized vent. Trench vents are not used for active collection systems.

Gas collection systems that will be evaluated can be categorized as either passive or active. A passive gas collection system utilizes the available pressure differential to effect gas release. As such, the gases are vented only intermittently, as is currently occurring at the East Hide Pile. An active system involves fan induced ventilation to extract the gases from the pile and therefore has greater flexibility to meet various gas generation rates.

3.3.2 Gas Control - Gas barriers such as synthetic membranes, clay layers, soil admixtures or asphalt are used in conjunction with a collection or venting system to convey gaseous emissions to a treatment system. When designing barriers, a chief consideration is rupture failure due to internal pressure buildup. Barriers utilizing clay, soil admixtures or asphalt do not contain emissions as well as synthetic membranes, therefore, critical pressure build up is not as likely to occur.

3.3.3 Gas Treatment - Several basic types of gas treatment are feasible including adsorption by carbon and thermal oxidation which will reduce emission odors below the detection level. The effectiveness of carbon adsorption is dependent upon the polarity of the compounds to be removed, for example, nonpolar organics such as benzene adsorb well. Carbon may also act as a catalyst to oxidize hydrogen sulfide gas. The efficiency of adsorption of hydrogen sulfide can be increased by impregnating the carbon with metal oxides.

A Calgon metal impregnated activated carbon, specially formulated for H_2S and mercaptan adsorption in oxygen free atmospheres, (Type FCA), could be used to adsorb emissions from a passive gas vent. However, the low emission rate would not ensure equal distribution through the carbon, increasing the likelihood of early odor breakthrough. Therefore, a passive venting system is unsuitable for carbon adsorption.

Another type of Calgon carbon specially treated for H_2S and mercaptan adsorption in the presence of oxygen, (Type IVP), could be used with an active venting system. Introduction of air would ensure good distribution through the carbon bed thereby prolonging the useful life of the system, reducing methane concentrations below the 5-15 percent explosive range, and providing the oxygen atmosphere required for IVP adsorption.

For the gaseous compounds emitted at the Woburn site, thermal oxidation also is a feasible treatment technique due to the combustible nature of methane, a principal component of the gases released from the East Hide Pile. Thermal oxidation systems include flares and incinerators. A flare is basically an ignition chamber in which an ignitable gas is allowed to combust in a controlled environment. Flaring could use methane as fuel which would reduce or eliminate fuel consumption. Gases below flammability limits, or that are not considered combustible, can be incinerated using a fuel mixture to achieve the required combustible content. Incinerators for gases and vapors burn fuel to maintain a temperature of up to 1,600 degrees F.

The estimated East Hide Pile emission of 2 ACFM containing 50 percent methane is too small for a normal flare. The John Zink Company would provide a self contained small incinerator, 0-10 ACFM capacity, with auxiliary fuel backup to maintain a combustion temperature of 1,400-1,600 degrees F. The incinerator would burn about 1.5 gph of liquid propane to maintain an exit temperature of 1,400-1,600 degrees F at a 2 ACFM emission rate. The consumption rate for propane is inversely proportional to the emission rate.

The incinerator would consist of a small brick lined combustion chamber with an automatic ignition, temperature control and flame safety feature. A 3,000 to 5,000 gallon liquid propane tank would supply fuel for a pilot and auxiliary fuel.

It was assumed that the 2 ACFM East Hide Pile emission contained 2 percent H_2S. The 1,400-1,600 degrees F combustion temperature would convert the H_2S to 0.4 lb/hour SO_2. The worst case SO_2 ground level concentration was calculated for a 30 foot stack with EPA guideline air model PTPLU. The maximum SO_2 concentration would be 8 ppb at a distance of 425 feet for stability class 4 at a wind speed of 1.5 feet/second (1.0 mile/hour). This compares to the Massachusetts primary ambient air standard of 30 ppb annual arithmetic mean, or a maximum 24 hour standard of 140 ppb.

3.4 Detailed Analysis of Odor Control Remedial Actions

Specification of Technologies Used

The technologies listed below were combined together to form three remedial action alternatives which are evaluated in the functional analyses.

Gas Emission Collection

- Pipe vents
- Trench vents
- Gas collection systems (active or passive)

Gas Emission Control

- Gas barriers

Gas Emission Treatment

- Carbon adsorption
- Thermal oxidation

A listing and discussion of the component parts for each of the three alternatives is presented below:

Alternative I (See Figure 3-2)

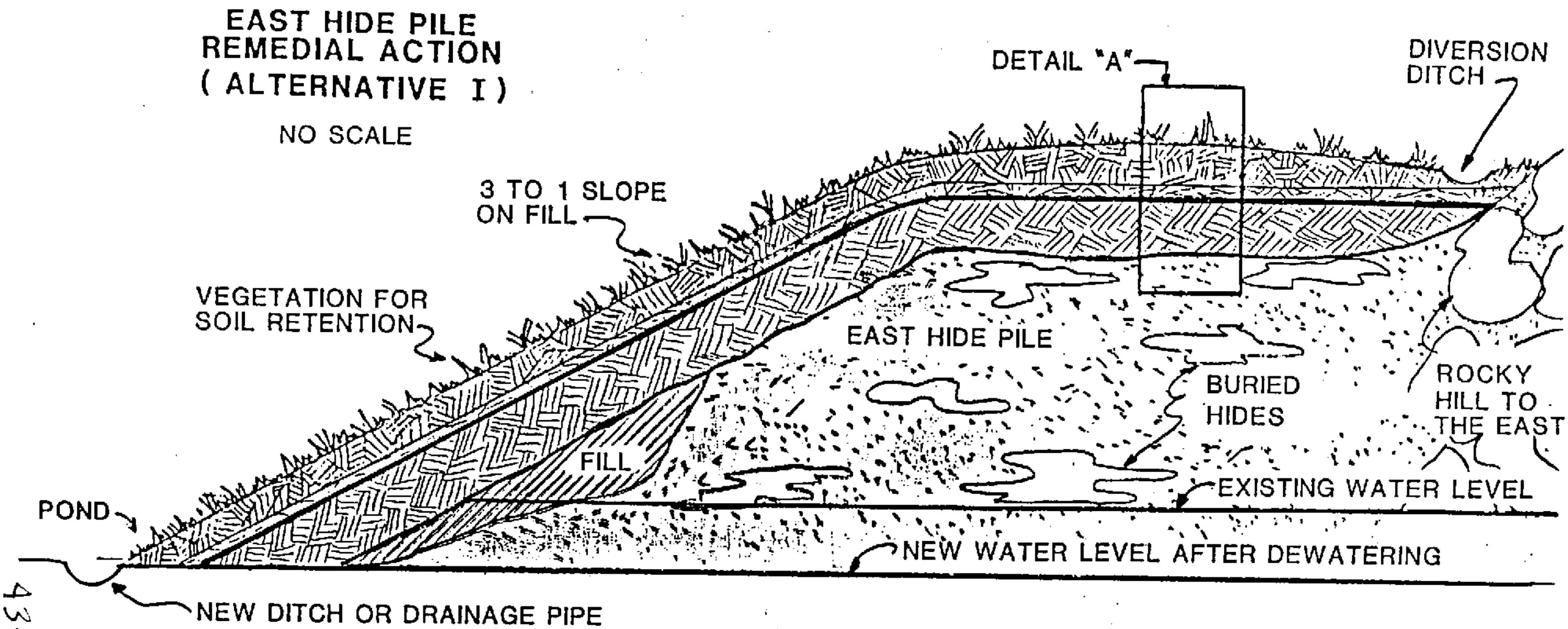
- Dewatering
- Modify slopes with new fill
- Install synthetic membrane liner cap
- Cover with topsoil and establish vegetation

Alternative II (See Figure 3-3)

- Dewatering
- Modify slopes with new fill
- Install gas collection system piping
- Install synthetic membrane liner cap
- Cover with topsoil and establish vegetation
- Blower system
- Carbon adsorption unit (Type IVP) after blower
- 12 foot stack

Alternative III (See Figure 3-4)

- Dewatering
- Modify slopes with new fill
- Install gas collection system piping
- Install synthetic membrane liner system
- Cover with topsoil and establish vegetation
- Blower system



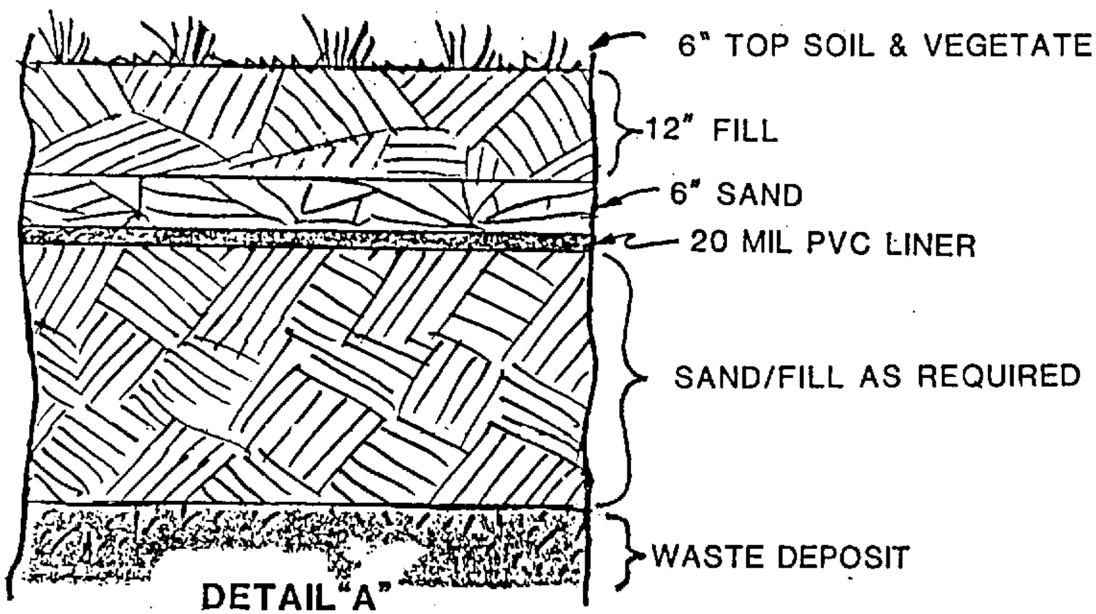
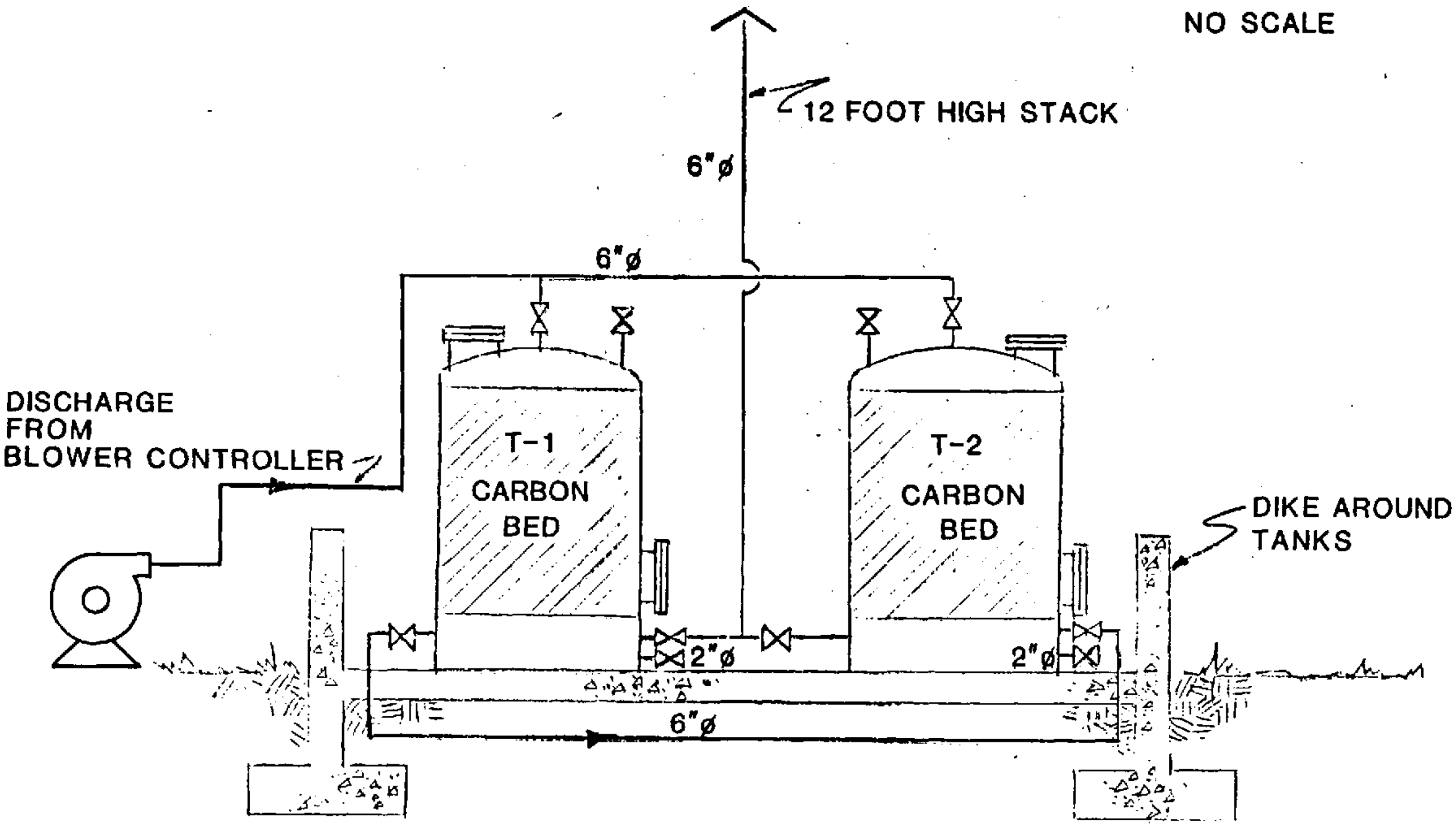


FIGURE 3-2

STAUFFER CHEMICAL COMPANY
WOBURN, MASS.

ALTERNATIVE II
(CARBON ADSORPTION)

NO SCALE



93-b

T-1 & T-2 8' DIA. x 6' HIGH 316 S/STL. WITH TOP MANHOLE, SIDE MANHOLE, FLUSH BOTTOM DRAIN, WITH INTERNAL SCREEN TO SUPPORT 6000 LBS. CALGON TYPE IVP CARBON BED

FIGURE 3-3

STAUFFER CHEMICAL COMPANY
WOBURN, MASS.

43-C

ALTERNATIVE III
(THERMAL OXIDATION)
NO SCALE

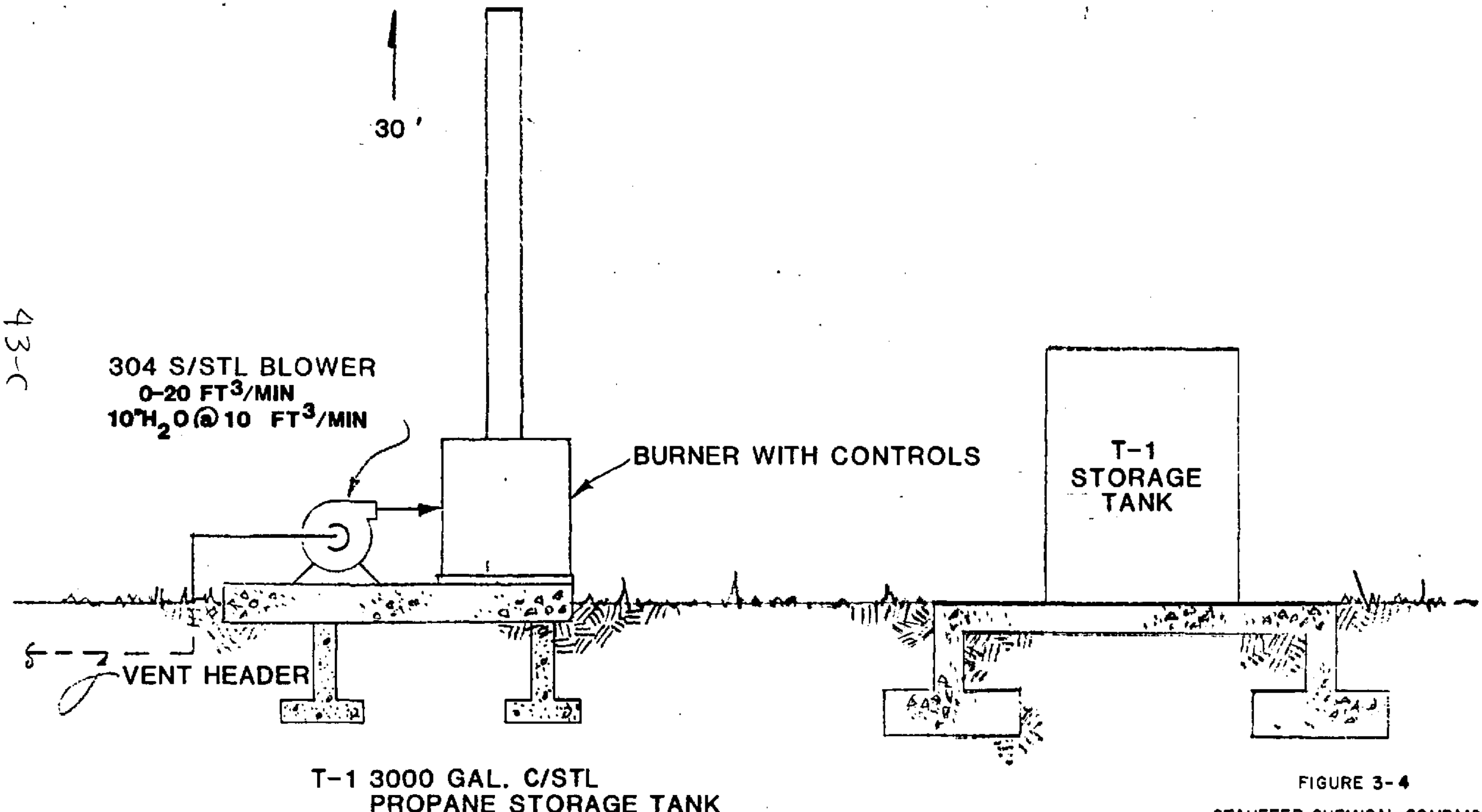


FIGURE 3-4

STAUFFER CHEMICAL COMPANY
WOBURN, MASS.

- Thermal oxidation unit after blower
- 3,000 gallon propane storage tank
- 30 foot stack

Alternatives II and III employ identical layers and controllers to collect and monitor gas emissions as illustrated on Figures 3-5 and 3-6. In this system of layers, new fill is used to modify the existing slopes as necessary. This fill allows emissions to migrate into the 12 inch layer of pea gravel where they are drawn into the exhaust blower via a network of perforated PVC piping. A 20 mil PVC liner prevents any further upward migration of the emissions and a 6 inch layer of sand further protects and secures the liner. Topsoil cover to a depth of 12 inches allows adequate root growth for a vegetative cover which reduces infiltration of rainwater.

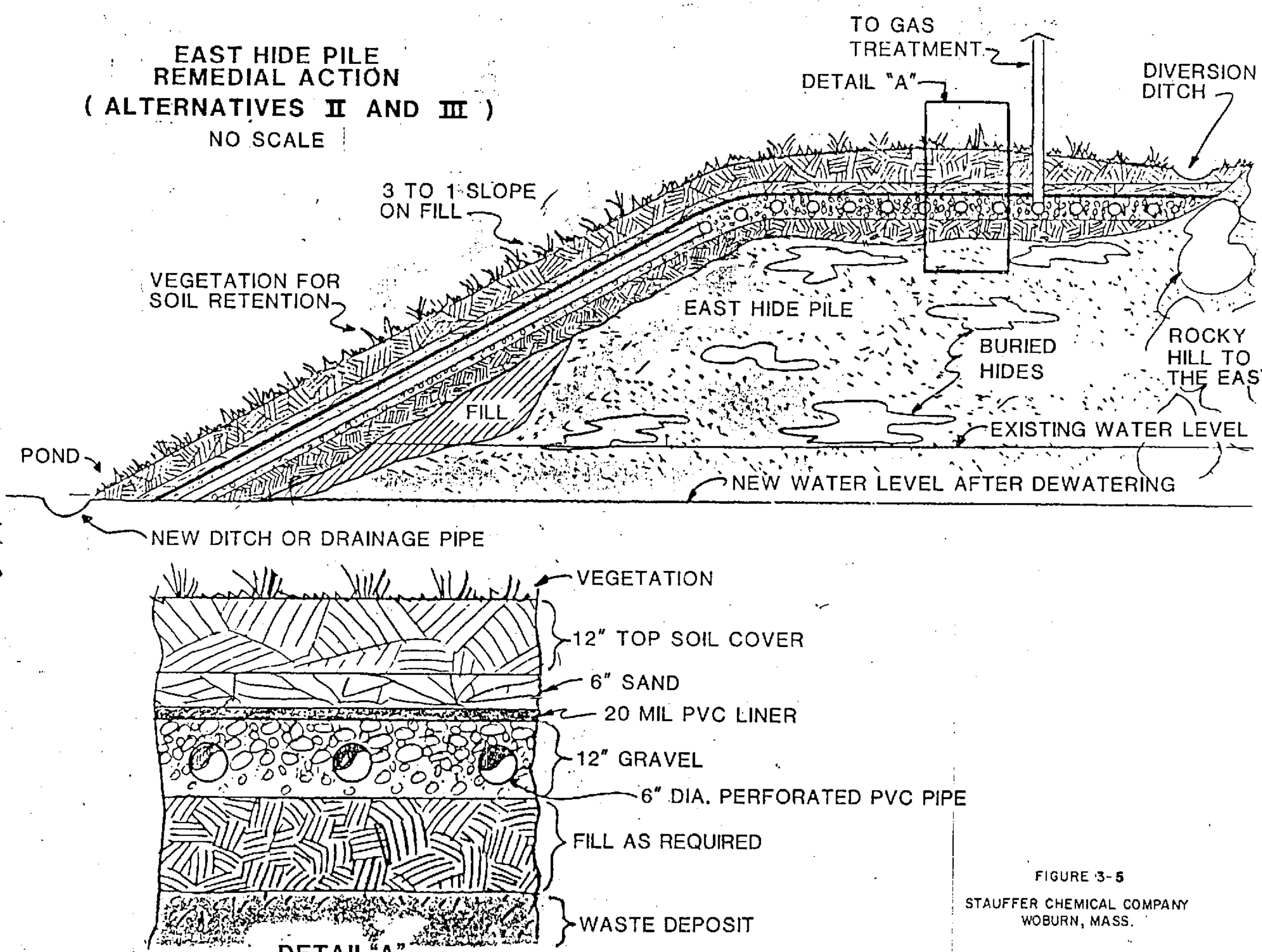
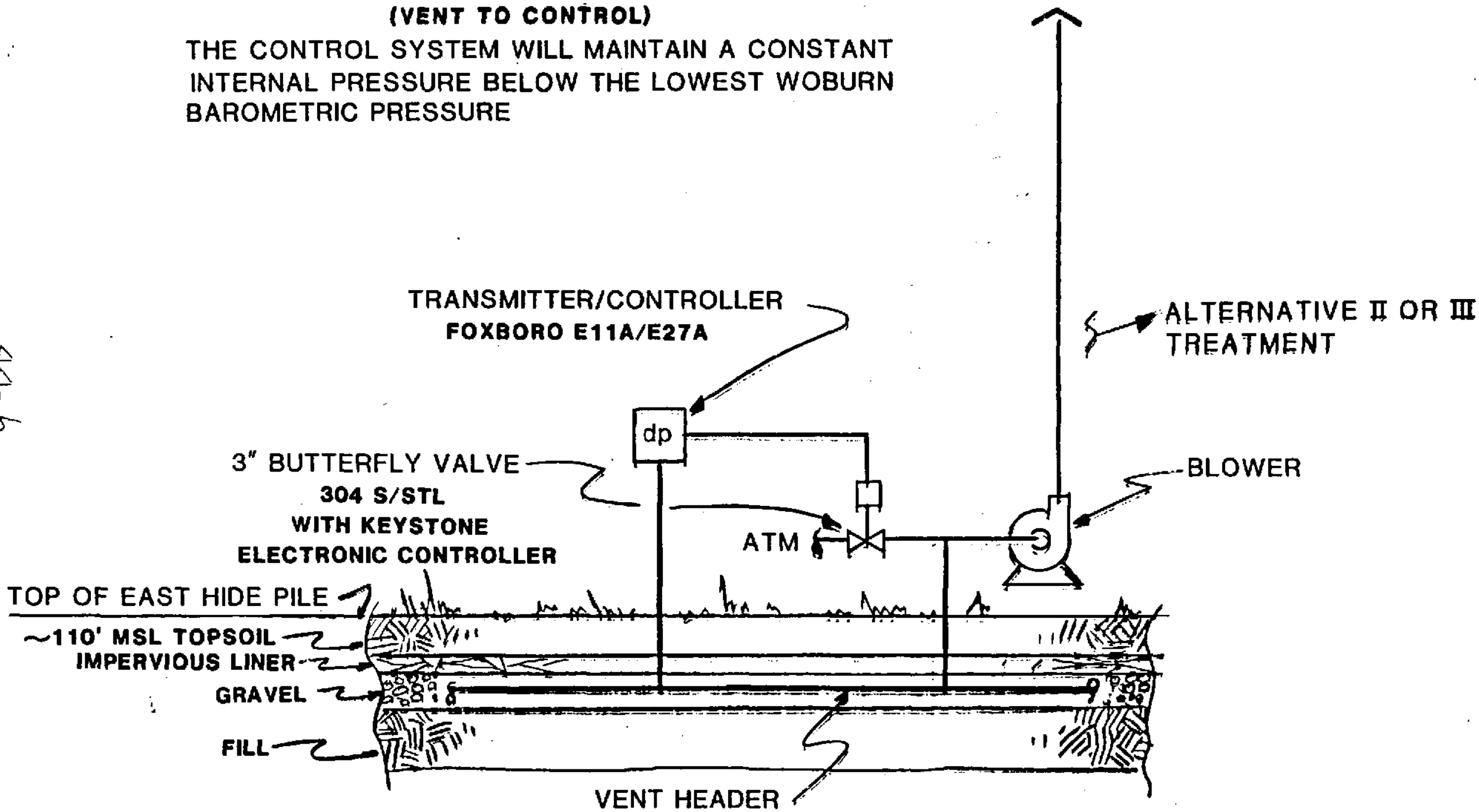


FIGURE 3-5

STAUFFER CHEMICAL COMPANY
WOBURN, MASS.

EAST HIDE PILE VENT CONTROL
(VENT TO CONTROL)

THE CONTROL SYSTEM WILL MAINTAIN A CONSTANT INTERNAL PRESSURE BELOW THE LOWEST WOBURN BAROMETRIC PRESSURE



NO SCALE

FIGURE 3-6

STAUFFER CHEMICAL COMPANY
WOBURN, MASS.

44-6

The process used to determine cover requirements for gas control and collection are presented below.

3.4.1 Gas Collection

Whether passive or active collection systems are selected for design, the logistics for the determination of cover requirements are the same. The primary design criteria for the cover are to: 1) minimize rainwater infiltration which affects sporadic gas discharge from soil void space displacement and which provides a moisture source to encourage gas production, and 2) minimize the gaseous release through highly impermeable cover material and direct the gas through a more permeable collection medium to a single outlet.

3.4.2 Gas Control

Minimizing rain water infiltration is a sound management strategy since a moisture source encourages anaerobic decomposition. Based upon previous experience and RCRA approved clay capping standards for leachate migration, clay caps with permeabilities of 1×10^{-7} cm/sec have been found to effectively reduce this rainwater infiltration. As such, gas generation will likely decrease over time if capping of the East Hide Pile is employed.

Gaseous release from a waste deposit is dependent on several factors, including the length of soil through which the gas must migrate, the permeability of this soil, and the available pressure differential, which acts as a driving force for gas movement. Gaseous release, therefore, can be described in accordance with the modified Darcy Flow equation:

$$Q = \frac{-k}{pg} \frac{A}{L} \Delta P$$

Where:

k = soil permeability (cm/sec.)
p = density of gas (g/cm^3)
g = acceleration of gravity ($cm/sec.^2$)
A = effective area (cm^2)
L = length of fluid migration (cm)
ΔP = pressure diffential ($g/cm\text{-}sec.^2$)

Thus, for a given set of soil conditions and a known gas, the equation may be reduced to:

$$Q = K_1 \Delta P$$

Where:

K_1 = soil specific permeability coefficient

Although comparison of K_1 values for different soils does not immediately indicate absolute values for flow rates, it does indicate relative permeabilities for different soil characteristics and geometries. In this manner, the relative resistance of current and projected waste deposit configurations and cover alternatives can be compared.

Based upon soil permeabilities measured at the bore hole locations and utilizing hydrogen sulfide as an indicator gas, the soil permeability coefficients for 24 inches of existing soil identified in the Phase II study are compared below to those representative of 24 inches of clay and a 20 mil PVC liner. Hydrogen sulfide was selected as an indicator gas since its low molecular weight makes it more amenable to diffusion and since it was found in the highest concentrations of all gases in bore hole samples.

	Permeability Coefficient
24-Inch Clay	0.17
20 mil PVC Liner	0.002
24-Inch Existing Soil	660

It is evident from the values above that the installation of a synthetic liner would significantly reduce the release of hydrogen sulfide through the cover soil. This is a result of the permeability of a synthetic liner being reported as 1×10^{-11} cm/sec compared to 1×10^{-7} cm/sec for clay. Other gases exhibit similar trends and equivalent relative permeabilities between cap types (as long as the particular gas emitted does not cause any unusual structural problems for the soil and is compatible with the synthetic membrane in question).

3.4.3 Gas Treatment

Carbon Adsorption - The carbon adsorption treatment in Alternative II would be added onto the discharge from the blower and utilize two Type IVP carbon beds in series. Each carbon bed would be contained in a 316 stainless steel tank, 8 feet in diameter and 6 feet high. Access to each 6,000 pound capacity carbon bed is provided by manholes located on the top and side of the tank. A reinforced concrete foundation would be designed to adequately support the treatment facility and a reinforced concrete dike would protect against spillage of caustic solution during carbon regeneration operations.

Inflow from the blower passes through a 6 inch diameter header system controlled with butterfly valves.

Thermal Oxidation - The thermal oxidation treatment in Alternative III would require a 3,000 gallon carbon steel propane storage tank. Adequate reinforced concrete support for the tank would be designed, including the slab and footings. Regulators and controls would monitor the gas temperature exiting the combustion chamber, and control the propane addition to maintain steady temperature.

Functional Analysis of East Hide Pile Alternatives

Table 3-1 indicates that the three highest ranking alternatives for remedial action at the East Hide Pile are:

- (Alternative I) Modify slopes with new fill, install synthetic membrane liner cap, cover with topsoil and establish vegetation

- (Alternative II) Modify slopes with new fill, install gas collection system piping, install synthetic membrane liner cap, cover with topsoil and establish vegetation, blower system, carbon adsorption unit after blower, and 12 foot stack

- (Alternative III) Modify slopes with new fill, install gas collection system piping, install synthetic membrane liner cap, cover with topsoil and establish vegetation, blower system, thermal oxidation unit after blower, 30 foot stack and propane storage tank.

TABLE 3-1

FUNCTIONAL ANALYSIS MATRIX -- FUNCTIONAL AREA: EAST HIDE PILE

Evaluation Criteria	Weighting Factor	Alternative I Rating	Alternative I Comment	Alternative II Rating	Alternative II Comment	Alternative III Rating	Alternative III Comment
1. Reliability	1.1	2	Pressure buildup may jeopardize cap	4	Carbons beds will require regular maintenance to assure reliability	4	Thermal oxidation requires inspection and maintenance to assure reliability
2. Constructibility	0.6	5	Common civil engineering methods	3	Treatment unit reduces constructibility	3	Treatment unit connection to gas collection piping reduces constructibility
3. Implementation Time Frame	0.5	5	Easiest to install due to minimal earthwork and lack of collection pipes	4	Installation of gas collection system and synthetic liner may involve slight delay	4	Installation of gas collection system and synthetic liner may involve slight delay
4. Environmental Effectiveness	2.0	1	Hydrogen sulfide gas may escape via ground water or fissures	4	Will treat emissions and assure negligible internal pressure buildup	4	Will treat emissions and assure negligible interal pressure buildup
Total		9.7		16.2		16.2	

Notes:

Ratings range from 1 (poor) to 5 (excellent).

Alternative I - Modify slope with new fill, install synthetic membrane liner cap, cover with topsoil, and establish vegetation

Alternative II - Modify slope with new fill, install gas collection system piping, install synthetic membrane liner cap, cover with topsoil, establish vegetation, carbon adsorption unit and 12-foot stack

Alternative III - Modify slope with new fill, install gas collection system piping, install synthetic membrane liner cap, cover with topsoil, establish vegetation, thermal oxidation unit and 30-foot stack, propane storage.

Evaluation of Engineering Implement-
ability and Constructibility

Alternatives II and III exhibit approximately equivalent implementability and constructibility. The construction and implementation sequence for either of these alternatives includes the following steps:

- Modify the East hide pile geometry with new fill to establish a maximum slope of three on one.
- Cover the pile with 12 inches of pea gravel as a gas collection medium.
- Place 6-inch PVC pipe within this medium for gas withdrawal.
- Cap the collection medium with a 20 mil synthetic membrane
- Cover with 6 inches of sand
- Cover the cap with 18 inches of soil/fill (to assure grass roots do not penetrate liner) and revegetate with grass.
- Attach a header and blower to the gas collection piping

Alternative I was judged to be much more constructible and implementable than Alternatives II or III due to the lack of collection piping and minimal earthwork required.

Evaluation of Reliability
and Environmental Effectiveness

The following similarities in construction of Alternatives II and III justifies the close ranking of reliability and environmental effectivenss in the functional analyses:

- The pea gravel used in Alternatives II and II provides a permeable layer within which generated gas may collect and be withdrawn through the collection piping.
- The synthetic liner cap used in Alternatives II and III prevents rainwater infiltration, which is a cause of: 1) gas release by soil void volume displacement; and 2) gas production by providing a source of moisture.
- The synthetic liner cap controls nonperiodic gas releases resulting from barometric pressure variations and allows the gases to be vented more effectively.

- The active gas collection system used in Alternatives II and III provides a constant gas removal mechanism and eliminates peak discharges.

Reliability and environmental effectiveness of Alternative I was ranked much lower than Alternatives II or III. The synthetic membrane cap may be jeopardized since internal pressure is likely to build up without any pressure release. Assuming however that the internal pressure does not become critical, it is possible that gaseous emissions could still escape through fissures or via ground water. Hence, the reliability and environmental effectiveness are questionable for Alternative I.

3.5 Cost Effective Ranking for Odor Control Alternatives

Table 3-2 summarizes the functional analysis values, capital costs, O&M costs and implementation costs for the selected alternatives for the East Hide Pile. The attached appendix contains tables which summarize the costs associated with the implementation of individual alternatives. Since slope stabilization is recommended, it also is recommended that the wetlands area between the East and West Hide Piles be drained to facilitate construction and stabilize side slopes. Therefore, installation of the 60-inch polypropylene culvert is required to divert runoff from the area between the hide piles. Additionally, it is recommended that following draining, the wetlands be covered and graded with clean fill to promote drainage, stabilize sidelopes and eliminate water infiltration to the East Hide Pile. This action enhances surface water runoff which facilitates a limitation of hide/water contact.

The recommended cost-effective ranking for the East Hide Pile is summarized below.

1. Modify slope with new fill, install gas collection system piping, install synthetic membrane liner cap, cover with topsoil and establish vegetation, blower and gas treatment system. Selection of the treatment system, either the carbon adsorption unit (Alternative II) or thermal oxidation unit (Alternative III) will be made following field tests.

2. Modify slope with new fill, install synthetic membrane liner cap, cover with topsoil and revegetate (Alternative I).

It was demonstrated in the Phase II report that the primary environmental concern with respect to the East Hide Pile is the release of odor-causing compounds. As such, remedial action alternatives were developed and design considerations were discussed in Section 3.4 that addressed methods of mitigating gas release and abating odor problems.

Alternative I, which does not include a gas collection system, is not considered cost effective since:

TABLE 3-2

COST COMPARISON OF SELECTED ALTERNATIVES FROM
EAST HIDE PILE FUNCTIONAL ANALYSIS RESULTS

Remedial Alternative/Description	Capital Cost	O&M Cost	Total Implementation Cost	Recommended Ranking	Ranking Rationale
I. Modify slopes with new fill, install synthetic membrane liner cap, cover with top soil and establish vegetation	$1.86 M[1]	$0[2]	$1.86 M	2	Questionable reliability and environmental effectiveness
II. Modify slopes with new fill, install gas collection system piping, install synthetic membrane liner cap, cover with topsoil and establish vegetation, blower system, carbon adsorption unit, 12 foot stack	$2.36 M	$0.30 M[3]	$2.66 M	1	To be evaluated during pilot testing
III. Modify slopes with new fill, install gas collection system piping, install synthetic membrane liner cap, cover with topsoil and establish vegetation, blower system, thermal oxidation unit, 3,000 gallon propane storage tank, 20 foot stack	$2.50 M	$0.50 M[3]	$3.00 M	1	To be evaluated during pilot testing

Notes:
1. Cost includes air monitoring. See Figure 3-7 for air monitoring flowchart.
2. O&M costs for Alternative I are considered zero because these costs are absorbed in the overall site monitoring.
3. O&M costs for Alternatives II and III are based on a 15-year life.

EAST HIDE PILE EMISSION MONITORING FLOWCHART

Cover East Hide Pile, cap with 20 mil PVC and install gas collection system. Start gas collection system and measure lb/day of TRS emitted at week 1 and 3.

TRS emission less than X lb/day

No

Yes

Measure TRS emissions at week 5 and 7

Install carbon adsorption system

Yes

TRS emission less than X lb/day

No

Install thermal oxidation system

TRS equals H_2S, mercaptans, sulfides, and disulfides.

FIGURE 3-7

50-6

- Treatment facilities are not provided in this alternative yet capital costs are not significantly different from Alternatives II or III, both of which provide gaseous treatment facilities.

- Generated gases can still migrate laterally through rock fissures or adjacent soils.

- Generated gases could become increasingly saturated in ground water under pressure induced by the impermeable barrier, and be released downgradient in the aquifer.

- Generated gases could build up internal pressure if not vented and ultimately threaten the integrity of the barrier.

Odor Control Recommended Alternative

East Hide Pile - The East Hide Pile requires modification of the slopes with new fill; installation of a gas collection and venting system, synthetic membrane liner cap, soil cover and revegetation. Collected gas treatment systems such as carbon adsorption or thermal oxidation will be evaluated during pilot scale testing. Figure 3-8 provides an architectural rendering of the installed carbon adsorption treatment atop the East Hide Pile.

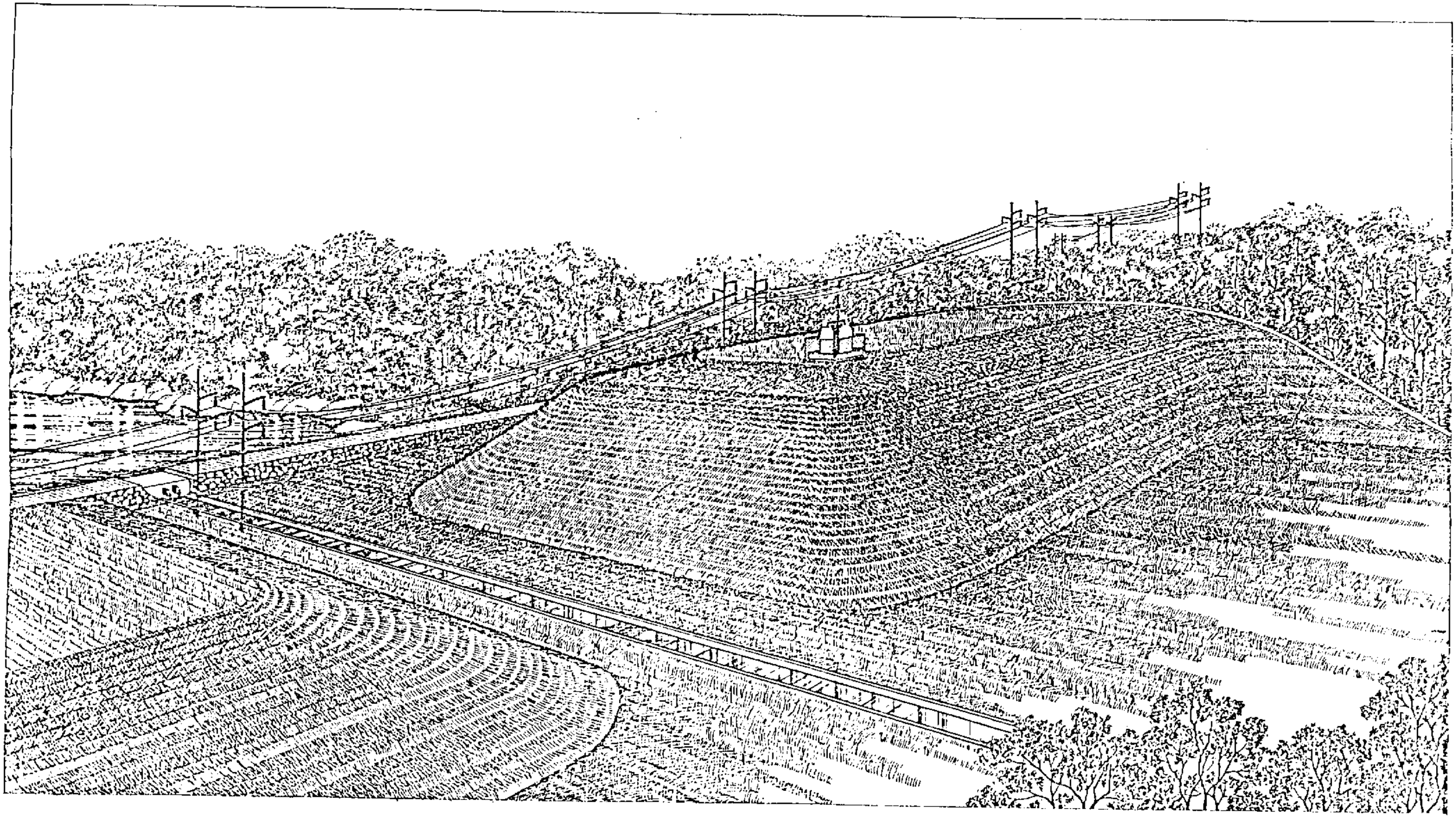


FIGURE 3-8

ARCHITECTURAL RENDERING OF
CARBON ADSORPTION TREATMENT
ON EAST HIDE PILE
FOR ODOR CONTROL

4.0 Contaminated Soils Remedial Program

Introduction

Nearly a century of chemical manufacturing and commercial activities have distributed metals in varying concentrations in the soil at Industriplex 128. The purpose of this section is to develop remedial measures to effectively mitigate possible hazards associated with contaminated soils.

As stated earlier, contaminated soils cover a majority of the site and vary in depth below grade. Major areas can be identified where more than one of the six metals investigated in Phase I and II sampling were measured at concentrations exceeding 1000 ppm. However, the endangerment assessment identified arsenic, chromium and lead as being the chief contaminated soil concerns. In addition, assessment of endangerment from wind blown off-site contamination also appears minimal. Accordingly, the major hazard to the general public is direct contact with surficial contaminants, principally arsenic, chromium and lead.

From a public health standpoint, the ten areas on the Woburn site that provide the most immediate potential hazard are:

A. East Hide Pile
B. West Hide Pile
C. East-Central Hide Pile
D. South Hide Pile
E. Arsenic pit and adjacent area
F. Chromium lagoons
G. Wedge Areas
H. PX Engineering, adjacent roadway and drainage ditch
I. Janpet Association
J. Stafford Engineering

The six heavy metals identified in the Phase II sampling include: arsenic, chromium, copper, mercury, lead, and zinc, which were selected from the Phase I sampling for further determination of their distribution on-site. Metal concentrations in the soil were measured with depth at 483 bore hole locations, (57 in Phase I and 426 in Phase II) and in ground water at on-site and off-site monitoring wells. Organic soil contamination was also investigated as part of the Phase I and Phase II site investigations. No organic waste deposits or sources of ground water contamination were found although a few isolated areas of organic contamination in the low ppm range were identified.

There is no significant ground water contamination resulting from soil-borne priority pollutant organic compounds or heavy metals. No sources of organic contamination were found in the soil and metals such as lead, arsenic, and chromium were not found to migrate from the soils to ground water in significant amounts.

Direct contact with surficial contaminated soils is a justifiable concern at the Woburn site, based upon the measured concentrations of arsenic, chromium, and lead. These metals are distributed in elevated concentrations over a large portion of the site. The distribution of each of the six identified metals is addressed in the following discussions.

Arsenic

Surficial concentrations of arsenic are illustrated on Plate 1 found in the attached appendix. On the Woburn site, basic areas where arsenic are found at concentrations greater than 100 ppm include:

- The arsenic pit and adjacent area
- Chromium Lagoons

The arsenic pit and adjacent area is highly eroded and no vegetation is evident, suggesting that arsenic and other metal concentrations may be phytotoxic. The chromium lagoon area has some vegetation established, although bare spots exist in these areas also.

Chromium

Surficial chromium concentrations are illustrated on Plate 2 found in the attached appendix. The major chromium deposits on the Woburn site are located in the chromium lagoon in the southern portion of the site.

Lead

Surficial lead concentrations are illustrated on Plate 3 found in the attached appendix. As in the case with copper, concentrations of lead greater than 100 ppm are scattered throughout the site. The highest concentrations appear to be located in the southern portion of the site both east and west of the Boston-Maine railroad.

Copper

Surficial copper concentrations are illustrated on Plate 4 found in the attached appendix. In general, copper is scattered throughout the site in concentrations greater than 100 ppm. Some of the higher concentrations are found at the locations associated with high arsenic and lead concentrations.

Mercury

Surficial mercury concentrations are illustrated on Plate 5 found in the attached appendix. Measured concentrations rarely exceeded 10 ppm, although one isolated sample exhibits a concentration of 200 ppm.

Zinc

Surficial zinc concentrations are illustrated on Plate 6 found in the attached appendix. In general, elevated concentrations above 100 ppm are prevalent throughout the site.

Summary of Existing Information

Since sporadic elevated concentrations of lead and arsenic in downgradient wells are not necessarily attributable to the Woburn site, and since wind-blown contamination does not appear to be a problem based upon samples collected during bore hole and test pit digging (see Endangerment Assessment), direct contact with metals is the major hazard attributable to contaminated soils. Therefore, remedial measures such as covering and revegetating will be implemented, to eliminate hazards due to surface contact, at the following locations.

- The West, East-Central and South Hide Piles
- The arsenic/phytotoxic area located south of the East and West Hide Piles
- The chromium lagoon area located west of the currently developed areas and east of the Boston-Maine Railroad
- The wedge area between New Boston Road and the Boston-Maine Railroad tracks
- A rectangular area owned by PX Engineering near the Boston-Maine Railroad on the northwest portion of the site, bordering the west side of New Boston Street
- The parcel in the central portion of the site owned by the Janpet and Stafford Associations

The East Hide Pile is not included for contaminated soil remedial action because the recommended gas control cover will eliminate the potential for direct contact.

4.1 Contaminated Soils Remedial Technologies

To develop appropriate technologies, a detailed literature search was conducted and past experience reviewed to identify generic approaches used to remediate contaminated soils. These approaches included:

4.1.1 Infiltration Control

- Grading and revegetation

- Grading/surface seals

    - Clay liner
    - Synthetic liner
    - Asphalt cover

4.1.2 Removal/Consolidation Technology

- Excavation and off-site disposal
- Excavation and consolidation on-site
- Excavation and land farming
- Excavation, encapsulation, and reburial
- Construction of RCRA Permitted Hazardous Waste Facility

4.1.3 Soil/Sediment Treatment

- Incineration
- Wet air oxidation
- Solidification
- Solution mining
- Neutralization/detoxification
- Microbial degradation

4.1.4 Access/Development Limitation

- Fencing

- Deed restrictions

- Six inch cover and vegetation over heavy metal contaminated areas

4.2 Identification of Woburn Site Specific Remedial Action Alternatives

The Phases I and II Site Investigations identified ten areas of potential concern with respect to contaminated soils. These included:

- East Hide Pile
- West Hide Pile
- East-Central Hide Pile
- South Hide Pile
- Janpet Engineering
- Arsenic Pit and adjacent areas
- Chromium Lagoons
- Wedge Area
- PX Engineering Area
- Stafford Engineering

Remedial technologies such as infiltration control, removal/consolidation, soil/sediment treatment and access/development limitations were applied to these potentially contaminated areas, collectively.

Infiltration Control(1)

- Regrade and revegetate contaminated materials to promote site drainage.
- Regrade and cap contaminated areas with clay material.
- Regrade and cap contaminated areas with a synthetic liner.
- Regrade and cap contaminated areas with an asphalt cover.

Removal/Consolidation

- Excavate contaminated areas to depth of water table with off-site disposal.
- Excavate contaminated areas to depth 6 inches below visual detection, with off-site disposal.
- Excavate contaminated areas to depth 6 inches below visual detection, consolidate between East and East Central Hide Piles, and cap.

Note:

1. Infiltration control alternatives will be evaluated independently and in combination for West, East, East-Central, South Hide Piles, Janpet Area, Phytotoxic Deposits, Chromium Lagoons, Arsenic Pit, Wedge Area and PX Engineering Area to ensure selection of effective remedial methods for the Woburn site.

- Excavate contaminated areas to depth 6 inches below visual detection, consolidate around East-Central Hide Pile, and cap.

- Excavate contaminated areas to depth 6 inches below visual detection, consolidate between East and East-Central Hide Piles, and cap.

- Excavate contaminated areas, construct RCRA-permitted hazardous waste facility, consolidate waste, cap according to RCRA regulations.

- Excavate and land farm contaminated areas.

- Excavate contaminated areas, encapsulate, and rebury on-site.

Soil/Sediment Treatment

- Incinerate excavated contaminated areas and dispose residue on- or off-site.

- Wet air oxidation of excavated contaminated areas and dispose residue on- or off-site.

- Cement-based solidification of contaminated areas.

- Lime-based solidification of contaminated areas.

- Thermoplastic-based solidification of contaminated areas.

- Organic polymer-based solidification of contaminated areas.

- Glassification-based solidification of contaminated areas.

- Apply solution mining technology to contaminated areas.

- Apply neutralization/detoxification technology to contaminated areas.

- Seed contaminated areas with micro-organisms to achieve degradation and stabilization.

Access/Development Limitations

- Surround site with chain link/barbed wire fence.
- Surround contaminated areas with chain link/barbed wire fence.
- Establish deed restrictions for contaminated area.
- Provide 6 inches of topsoil where necessary and vegetate.

4.3 Screening Methodology

Based upon the specific alternatives developed, two stages of screening were conducted. First, alternatives which are not feasible are omitted from further consideration. Those alternatives and the associated omission rationale are shown below:

WASTE DEPOSIT AND CONTAMINATED SOIL/SEDIMENT CONTROL
REMEDIAL METHODS OMITTED FROM FURTHER CONSIDERATION

Remedial Method	Omission Rationale
Soil/Sediment Treatment	
1. Stabilization/solidification/ reburial	Cost, Environmental Effectiveness, Negative Environmental Impact Potential, Feasibility and Reliability: Cost of encapsulation/reburial of any or all of the wastes on-site is an order of magnitude greater than burial alone. Wastes must undergo thorough analytical characterization and pilot stabilization testing to ensure compatibility with a specific waste. The heterogeneous nature of the hide piles renders this technique infeasible.
2. Encapsulation/reburial	Feasibility and Reliability: The encapsulation process has yet to be applied on a large commercial scale under actual field conditions.
3. Incineration/residue reburial	Feasibility and Reliability: Incineration is infeasible for heavy metal removal.
4. Wet air oxidation/residue reburial	Same rationale as No. 3 above.
5. Land farming	Feasibility and Reliability: Landfarming infeasibile for heavy metals removal.
6. In situ microbial degradation	Same rationale as No. 5 above.

WASTE DEPOSIT AND CONTAMINATED SOIL/SEDIMENT CONTROL
REMEDIAL METHODS OMITTED FROM FURTHER CONSIDERATION
(Continued)

Remedial Method	Omission Rationale
7. In situ solution mining	Feasibility and Reliability: Requires homogeneous waste that is mobile and that can be entrained in a solvent phase, contaminants in the soils have proven immobile over time and hide piles present a very heterogeneous environment.
8. In situ neutralization/ detoxification	Feasibility and Reliability, Negative Environmental Impact Potential: Heterogeneous nature of wastes result in the potential for poor contact with neutralization medium. Toxic by-products could be generated as a result of the heterogeneous mixture of wastes and presence of heavy metals.

In the second screening stage, the retained alternatives described below are evaluated in more detail:

WASTE DEPOSIT AND CONTAMINATED SOIL/SEDIMENT
CONTROL REMEDIAL METHODS RETAINED FOR FURTHER EVALUATION

Remedial Method	Retention Rationale
1. Regrade and clay cap	Environmental Effectiveness: Capping the waste deposits and contaminated soils/sediments achieves the remedial objectives of preventing surface contact.
2. Regrade and cap with synthetic liner	Same as above.
3. Fencing and deed restrictions	Cost: The possibility of immediate land development and the short-term prevention of human access.
4. Excavation and construction of RCRA-permitted hazardous waste facility	Environmental Effectiveness: Reburial of excavated waste and/or contaminated soil in a secure landfill-type environment has been an acceptable means of disposal.
5. Relocation/consolidation of excavated material	Environmental Effectiveness and Cost: Utilization of wastes and contaminated soils as intermediate fill for regrading reduces costs of grading/cover/capping alternatives. It also increases the implementability of the cover/capping alternatives.
6. No action	Cost: The possibility of immediate land development and the establishment of cover over some contaminated areas protects long-term environmental degradation.
7. Regrade, cover with 6 inch soil, vegetate and deed restrictions	Environmental Effectivenss: Implementation would provide protection against surficial contact, promote runoff and reduce infiltration and not limit future development

Description of Retained Remedial Alternatives

Excavation - Contaminated soil and waste deposits on the Woburn site are amenable to removal by mechanical excavation. The waste deposits are surficial, generally, extending from 0 to 10 feet in depth. Therefore, excavation by backhoe or front-end loader is appropriate.

Based on past on-site excavation experience, contaminated areas can be identified by visual means. This is based on abrupt changes noted in soil color between clean areas corresponding to approximately 100 ppm levels, and those areas exhibiting higher metal concentrations. An additional cut of six inches shall be sufficient to reasonably assure that most, if not all, of the contaminated soil is removed. The chief advantage of visual identification versus repeated sampling and analysis is quicker implementation.

Any excavation in and around the Janpet Associates property must be implemented with care due to the existence of abandoned sewer lines. The known locations of abandoned sewer lines is shown on Figure 4-1. Some environmental risks are involved with excavation. Disturbing cover material on the hide piles will result in release of odors. Therefore, extensive monitoring will be required during excavation in and around these areas. Disturbing waste deposits in contact with ground water may result in bulk contaminant release to the aquifer. However, should contaminants be released, they can be adsorbed in the soil or recovered by downgradient pumping.

Consolidation - Two on-site consolidation alternatives were considered for contaminated soils; however, only one alternative has enough capacity to store 459,000 cubic yards. The feasible alternative would consolidate between the East and East-Central hide piles as shown on Figure 4-2. This option could provide storage for approximately 675,000 cubic yards based on the assumption that the profiles are correct, for the entire width, throughout the indicated coordinates.

Disposal of Excavated Material - Excavated material from the Woburn site can be disposed of in the following manners:

- On-site consolidation
- On or off-site in a RCRA-approved landfill
- On-site in a designated area
- On-site "in situ"

A RCRA landfill on or off-site could be used to dispose of wastes in a secure ultimate facility. Once relocated, the contaminated waste would be graded to a maximum one vertical on three horizontal slope with a bulldozer or road grader. The relocated wastes can be covered and/or capped as outlined in the following section.

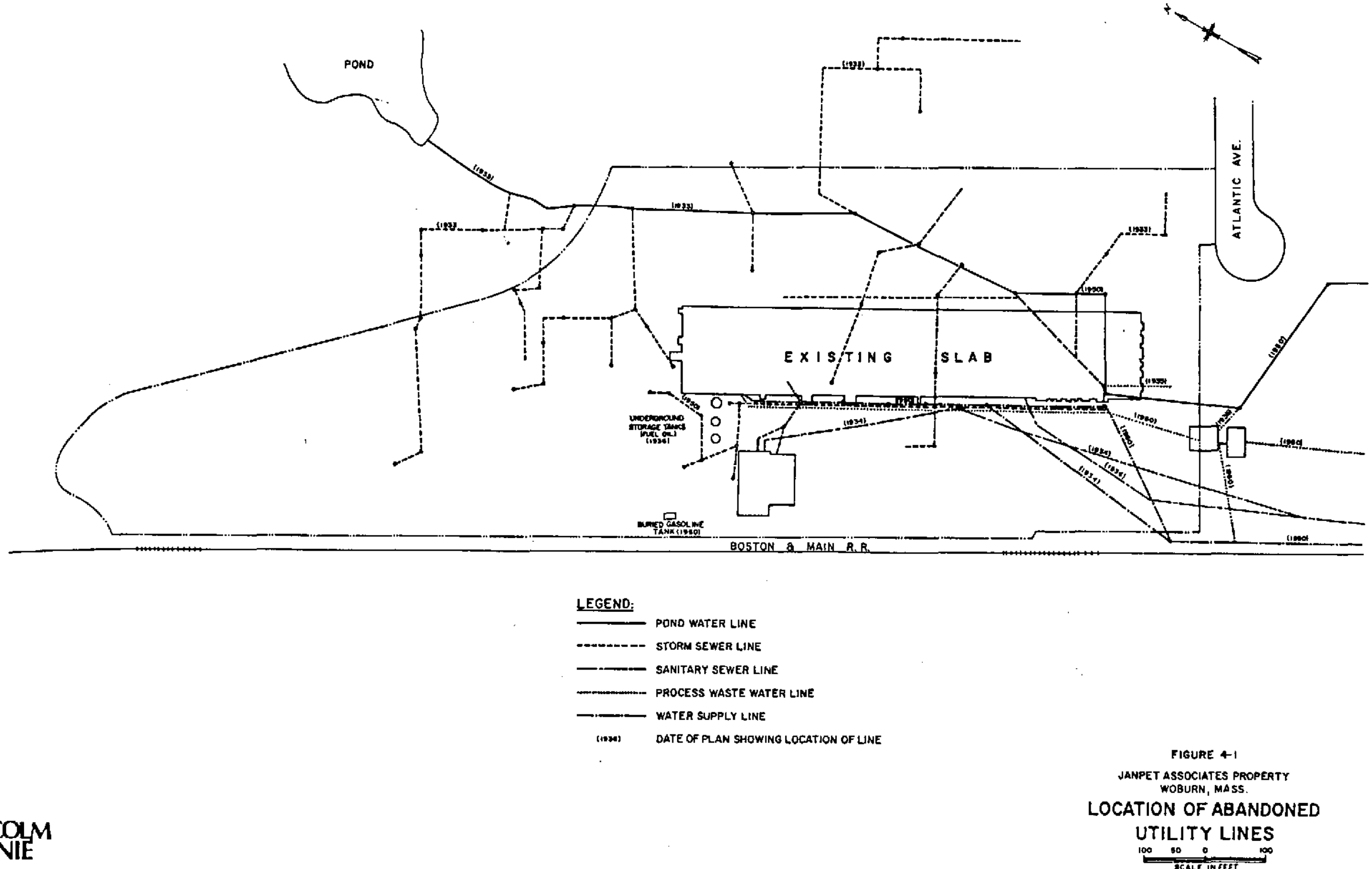


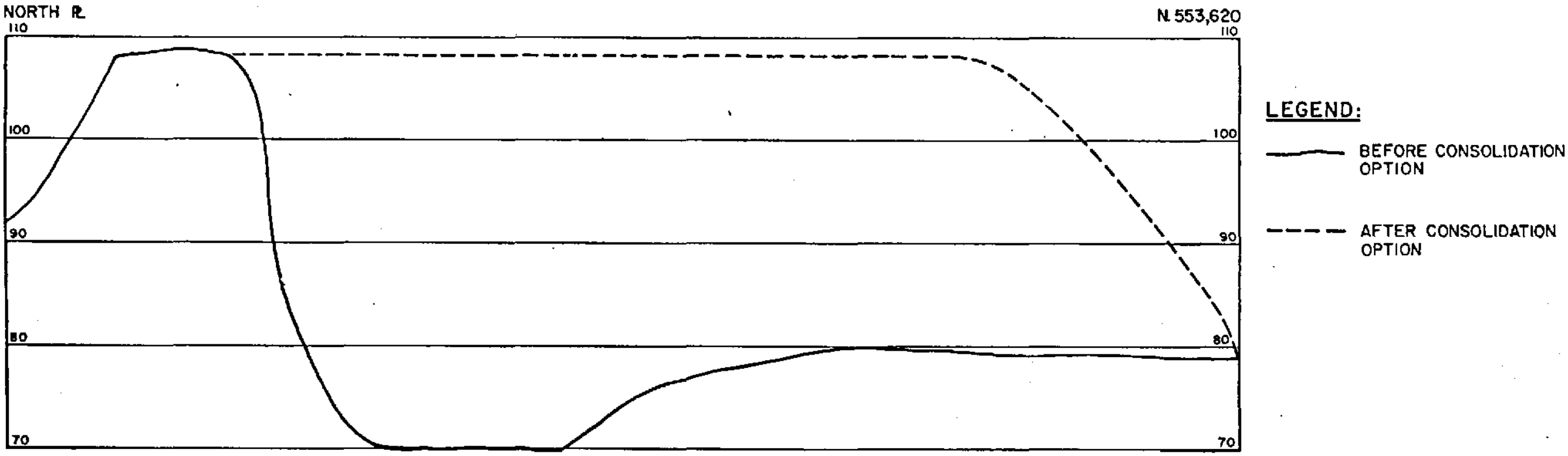
FIGURE 4-1

JANPET ASSOCIATES PROPERTY
WOBURN, MASS.

LOCATION OF ABANDONED UTILITY LINES

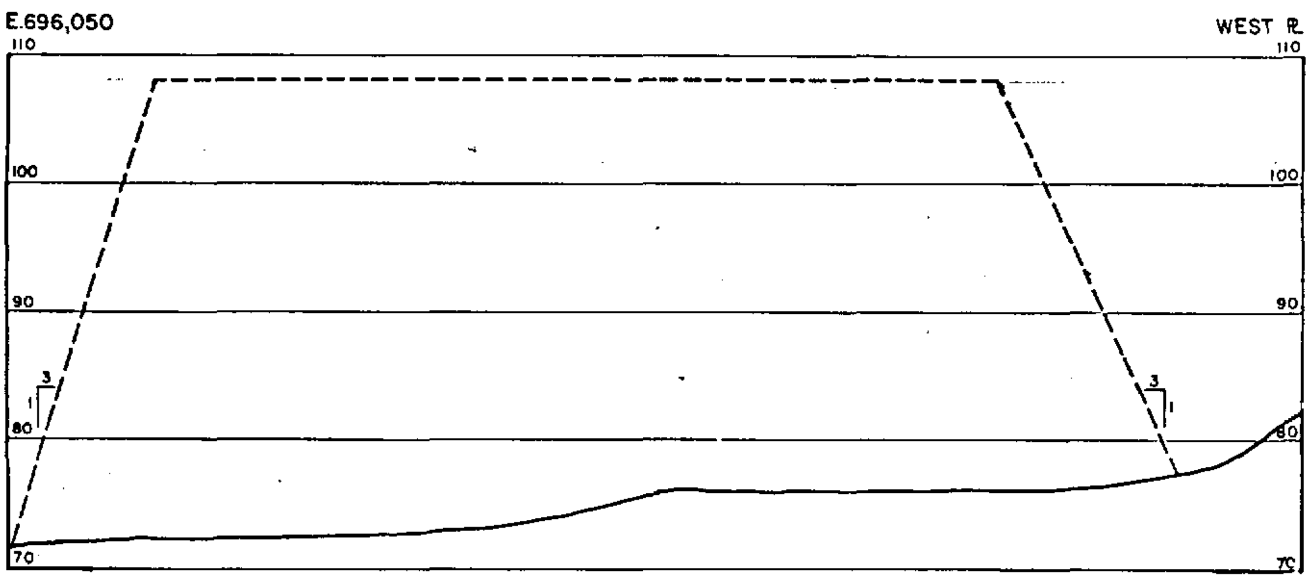
MALCOLM PIRNIE

01-2



PROFILE OF E.696,300 BETWEEN NORTH ℞ AND N.553,620

9-19



PROFILE OF N.554,222 BETWEEN E.696,050 AND WEST ℞

FIGURE 4-2

STAUFFER CHEMICAL COMPANY
WOBURN, MASS.

PROFILES OF EAST & EAST-CENTRAL HIDE PILE AREAS FOR CONSOLIDATION OPTION

SCALE: HOR. 1" = 70'
VERT. 1" = 7'

Surface Treatment and Capping - The objective of surface treatment and capping is to prevent surface contact and reduce infiltration. Capping also can be employed to mitigate and redirect gas release from the animal hide deposits releasing gases. This is accomplished by placing a relatively impermeable clay liner or synthetic membrane above the deposit. For example, a 6-inch clay cap can reduce the permeability of a typical soil deposit at the Woburn site from 1×10^{-2} cm/sec to 1×10^{-7} cm/sec. A 20 mil synthetic liner can reduce permeability further to 1×10^{-11} cm/sec. Suitable cover material such as topsoil or loam would then be placed on top of the cap to provide a medium through which rainfall can be transported away from the protected waste deposit, and provides a base on which to establish vegetation. Because of the reduced permeability of the capped areas, asphalt channels or gravel swales are often installed around a capped site to route the runoff to an appropriate drainage system, and to prevent flooding. A typical surface capping cross-section is illustrated on Figure 4-3.

The waste area can be regraded or modified with relatively permeable fill to one vertical on three horizontal slopes with a bulldozer or road grader prior to capping. If gas production is a concern, as in the instance of the East Hide Pile, the permeable fill layer between the waste deposit and the impermeable cap provides a volume in which the gas may collect prior to venting.

The impermeable cap or liner would be installed on top of the permeable fill. If clay is used, either local clay would be purchased or, as seems more likely, Wyoming bentonite clay would be mixed with native soils to produce a barrier with an effective permeability of 10^{-7} cm/sec. In order to avoid confusion in future discussions, "clay" will be understood to mean either of the two possible capping materials. Blending of the native soil/bentonite clay mixture is accomplished with an agricultural disk or rototiller, and compaction is achieved with a wobble wheel or steel drum roller. If an impervious liner is used, it would be placed below clean fill or sand.

Topsoil or loam is placed over the impermeable cap to support vegetation. These layers vary between 6 and 12 inches. The major benefits of revegetation are the reduction in surficial erosion by wind and water and infiltration control by means of vegetative evapotranspiration.

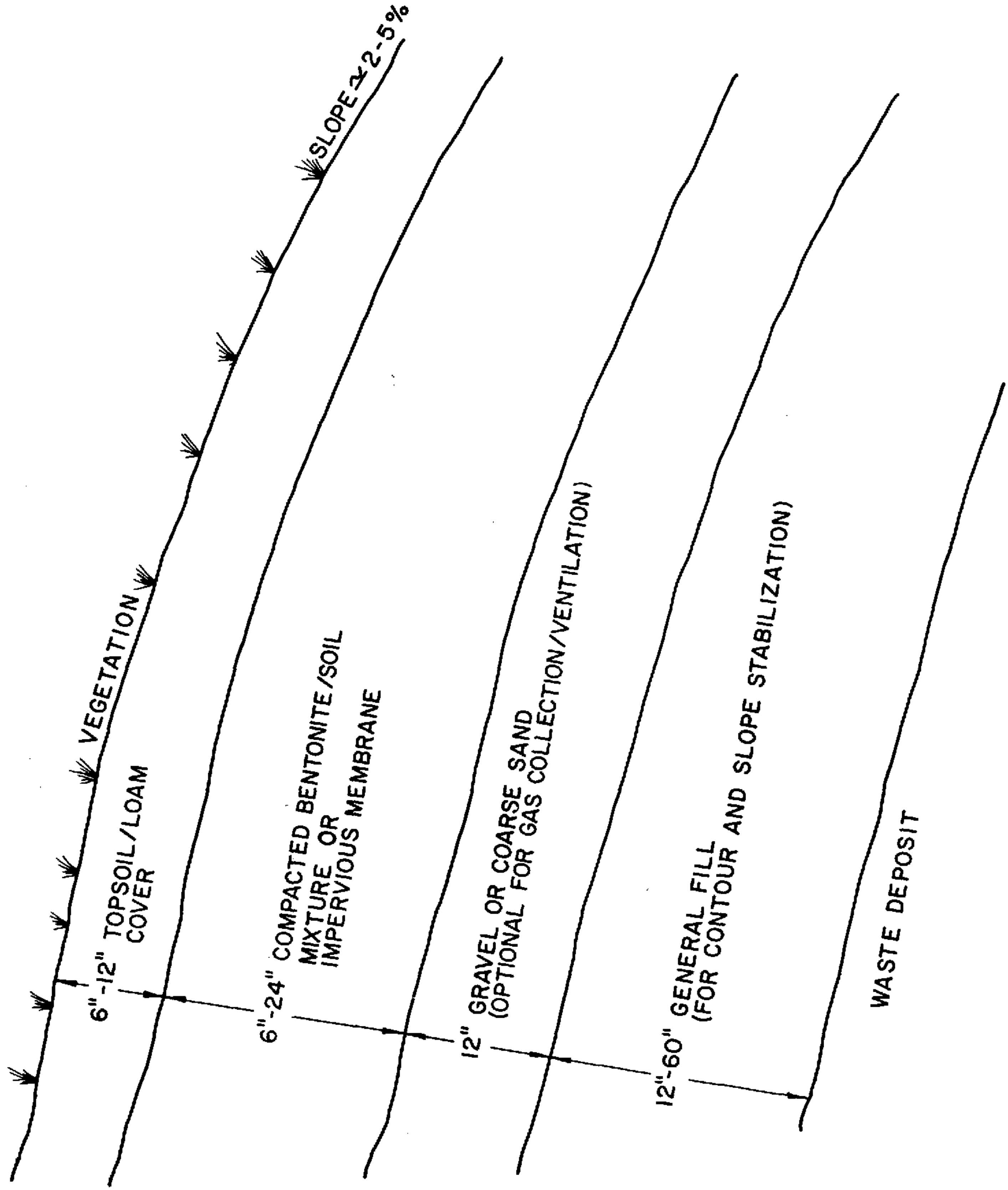


FIGURE 4-3

REMEDIAL ACTION EVALUATION

CROSS-SECTION OF TYPICAL SURFACE CAPPING INSTALLATION

Fencing - Fencing is provided to prevent accidental contact in areas where soil contamination is localized and health hazards as a result of direct contact with soils are uncertain. Fenced areas are posted with no trespassing, private property, and other applicable warning signs.

Deed Restrictions - Deed restrictions would provide guidance for future site development in areas which are suspected of being contaminated and in which remedial measures have been undertaken. Deed restrictions would include:

- A description of the contaminated material.
- Required construction methods for preserving the effectiveness of the implemented remedial measure.
- Methods by which the implemented remedial measure can be replaced to assure continued effectiveness (e.g., replacement of capping material).
- Methods by which construction activity will be conducted and monitored to ensure worker safety.

No Action - Since it does not appear that metal contaminated leachate is migrating off-site, a no action alternative is plausible. However, the no action alternative will not prevent possible surface exposure.

4.4 Detailed Analysis of Contaminated Soils Remedial Actions

Eleven feasible remedial alternatives were identified, for either of the two areas listed below, based on technologies previously listed.

- Concentrations greater than or equal to 100 ppm and the East Hide Pile (74.0 acres). The East Hide Pile occupies 3.8 acres.

- Concentrations greater than or equal to 300 As and/or 600 ppm Pb and/or 1,000 ppm Cr ppm and the East Hide Pile (45.1 acres).

Alternatives I-IX evaluate areas with As, Cr, or Pb greater than 100 ppm. Alternatives X and XI evaluate areas greater than or equal to 300 ppm As and/or 600 ppm Pb and/or 1,000 ppm Cr. The candidate alternatives will be identified and the associated advantages and disadvantages will be discussed. Table 4-1 provides a functional evaluation for the five criteria listed in Section 1.0 for contaminated soils.

Alternative I (24-Inch Clay, 6-Inch Cover, Vegetate)

Work Items

- Cut, fill, regrade top 12 inches of existing soil to develop new contours, eliminate water pockets, and promote better drainage.

- Cover area with a 24 inch layer of Wyoming bentonite/soil mixture having an effective permeability of 10^{-7} cm/sec and compacted in 6-inch lifts

- Cover clay barrier with a 6 inch layer of top soil and vegetate

- Additional work:

  - Surveying to verify cuts and fills and test borings to delineate contamination

  - Install 60-inch drain to dewater swampy areas in order to stabilize hide pile slopes before adding cover

  - Mobilization and demobilization of equipment

Advantages

- Reduced infiltration due to regraded slopes and vegetation will result in increased surface runoff and minimize the potential for ground water contamination.

TABLE 4-1

FUNCTIONAL ANALYSIS MATRIX -- FUNCTIONAL AREA: CONTAMINATED SOILS

	Weighting	Alternative I		Alternative II		Alternative III		Alternative IV	
Evaluation Criteria	Factor	Rating	Comment	Rating	Comment	Rating	Comment	Rating	Comment
1. Reliability	1.1	4	Reduces both potential for contact and rainwater infiltration	4	Reduces both potential for contact and rainwater infiltration	4	Reduces both potential for contact and rainwater infiltration	4	Reduces both potential for contact and rainwater infiltration
2. Constructability	0.6	4	Common civil engineering technique	4	Common civil engineering technique	4	Common civil engineering technique	4	Common civil engineering technique
3. Impelmentation Time Frame	0.5	3	Compaction required for large soil volume	3	Compaction required for large soil volume	4	Less layers than Alternatives I and II	2	More layers than Alternatives I and II
4. Environmental Effectiveness	2.0	4	Some portions of site may be difficult to completely seal	3	Additional infiltration compared to Alternatives I and IV	4	Would treat metals in ground water if necessary	4	Some portions of site may be difficult to completely seal
5. Future Land Use	0.5	1	Precludes development on 70 acres	1	Precludes development on 70 acres	3	Does not preclude development. Requires deed restrictions.	1	Precludes development on 70 acres
Total		16.8		14.8		18.3		16.3	

Note:

Ratings range from 1 (poor) to 5 (excellent).
Alternative I - 24" clay, 6" cover, vegetate.
Alternative II - 6" clay, 18" fill, 6" cover, vegetate.
Alternative III - 24" offsite fill, 6" cover, vegetate
Alternative IV - 20 mil PVC liner, 12" sand beds, 12" fill, 6" cover, vegetate

TABLE 4-1

FUNCTIONAL ANALYSIS MATRIX -- FUNCTIONAL AREA: CONTAMINATED SOILS (Continued)

Evaluation Criteria	Weighting Factor	Alternative V Rating	Alternative V Comment	Alternative VI Rating	Alternative VI Comment	Alternative VII Rating	Alternative VII Comment	Alternative VIII Rating	Alternative VIII Comment
1. Reliability	1.1	3	Reduces potential for contact	4	Allows future site develop-on portion of property and minimizes poten-tional for contact	5	Allows site development on large portion of property	5	Allows site development on large portion of property
2. Constructibility	0.6	5	Common Civil engin-eering methods	2	Requires access roads, reloca-tion system design and leachate collec-tion system	2	Requires safety precautions and coordination	2	Requires safety precautions and coordination
3. Implementation Time Frame	0.5	5	Short-term due to minimal earthwork required	1	Long-term due to large volume of soil being excavated and and relocated fill required	1	Long-term due to large volume of soil being excavated, relo-cated and back-	2	Less time than Alternative VII since no back-fill required
4. Environmental Effectiveness	2.0	3	Would treat metals in ground water if necessary	3	Excellent long-term effective-ness due to odor	4	Would limit infil-tration and gaseous emissions	4	Would limit in-filtration and gaseous emissions
5. Future Land Use	0.5	4	Does not preclude development of site. Requires deed re-strictions.	3	Precludes development on 13.6 acres	3	Precludes development on 15 acres	3	Precludes development on 15 acres
Total		16.8		13.6		16.7		17.2	

Note:

Ratings range from 1 (poor) to 5 (excellent)
Alternative V - 6 inch cover, vegetate, deed restrictions
Alternative VI - Construct RCRA landfill
Alternative VII - Consolidate and cover with 24" backfill, 6" soil, backfill
Alternative VIII - Consolidate and cover with 24" backfill, 6" soil, no backfill

TABLE 4-1

FUNCTIONAL ANALYSIS MATRIX -- FUNCTIONAL AREA: CONTAMINATED SOILS (Continued)

Evaluation Criteria	Weighting Factor	Alternative IX Rating	Alternative IX Comment	Alternative X Rating	Alternative X Comment	Alternative XI Rating	Alternative XI Comment
1. Reliability	1.1	3	Reduces potential for contact	4	Allows future site development on portion of property and minimizes potential for contact	3	Reduces potential for contact
2. Constructibility	0.6	5	Limited excavation, fence and deed restrictions	4	Common civil engineering technique	5	Common civil engineering technique
3. Implementation Time Frame	0.5	4	Readily implemented	4	Readily implemented	4	Short-term due to less earthwork required
4. Environmental Effectiveness	2.0	2	Would treat metals in ground water if necessary. Less cover than other options.	4	Would treat metals in ground water if necessary	3	Would treat metals in ground water if necessary
5. Future Land Use	0.5	5	Does not preclude development. Required deed restrictions	4	Does not preclude development. Required deed restrictions.	4	Does not preclude development. Required deed restrictions
Total		14.8		18.8		16.3	

Note:

Ratings range from 1 (poor) to 5 (excellent)

Alternative IX - Limited excavation and relocation of ditch along New Boston Streets, fence and deed restrictions

Alternative X - Limited excavation and relocation of ditch along New Boston Street, fence and deed restrictions. Cover areas in top 2 feet greater than either 300 ppm As, 600 ppm Pb or 1,000 ppm Cr with 30 inch fill/soil.

Alternative XI - Limited excavation and relocation of ditch along New Boston Street, fence and deed restrictions. Cover areas in top 2 feet greater than either 300 ppm As, 600 ppm Pb or 1,000 ppm Cr with 6" fill/soil

- Compacted 24-inch layer of relatively impervious Wyoming bentonite/soil mixture provides an excellent barrier against rain infiltration and gaseous release.

- Cover system meets RCRA interim status requirements

- Potential migration to surface water is reduced as well as direct contact

Disadvantages

- 380,000 cubic yards of fill/clay needed for 100 ppm areas which could result in potential adverse impacts to neighboring roads over a 19-month period.

- Wetlands must be dewatered to stabilize East and West hide pile slopes before adding cover.

- Portions of the site such as the Boston-Maine railroad track ROW and buildings may be impossible to seal with clay. This could possibly undermine the reliability of Alternative I.

- Provides little additional benefit to environment compared to Alternative V and backup ground water metal treatment implementation.

- Precludes future site development on 70 acres for 100 ppm limit.

- Certain portions of the waste are below the water table. Alternative I would not substantially reduce the volume of contaminated soil in contact with ground water.

Alternative II (6-Inch Clay, 18-Inch Fill, 6-Inch Cover, Vegetate)

Work Items

- Cut, fill, regrade top 12 inches of existing soil to develop new contours, eliminate water pockets, promote better drainage.

- Cover area with a compacted 6 inch layer of Wyoming bentonite/soil mixture having an effective permeability of 10^{-7} cm/sec.

- Cover clay barrier with 18 inch layer of off-site fill.

- Cover fill with 6 inches of top soil and vegetate.

- Additional Work:

  - Surveying to verify cuts and fills and test borings to delineate contamination

  - Install 60-inch drain to dewater swamp areas in order to stabilize hide pile slopes before adding cover

  - Mobilization and demobilization of equipment

Advantages

- Reduced infiltration due to regraded slopes and vegetation will result in increased surface runoff and minimize the potential for ground water contamination.

- Compacted 6 inch layer of relatively impervious Wyoming bentonite/ soil mixture provides a very good barrier against rain infiltration and gaseous release.

Disadvantages

- 380,000 cubic yards of fill/clay needed for 100 ppm areas which could result in potential adverse impacts to neighboring roads over a 19 month period.

- Portions of the site such as the Boston-Maine railroad tracks may be impossible to seal with clay. This could possibly reduce the reliability of Alternative II.

- Wetlands must be dewatered to stabilize East and West hide pile slopes before adding cover.

- Precludes future site development on 70 acres for 100 ppm limit.

- Certain portions of the waste are below the water table. Alternative II would not substantially reduce the volume of contaminated soil in contact with ground water.

Alternative III (24-Inch Off-Site Fill, 6-Inch Cover, Vegetate)

Work Items

- Cut, fill, regrade top 12 inches of existing soil to develop new contours, eliminate water pockets, promote better drainage.

- Cover area with 24 inch layer of off-site fill.

- Cover fill with 6 inches of top soil and vegetate.

- Additional Work:

  - Surveying to verify cuts and fills and test borings to delineate contamination

- Install 60-inch drain to dewater swampy areas in order to stabilize hide pile slopes before adding cover

- Mobilization and demobilization of equipment

Advantages

- Quicker implementation time.
- Minimizes potential for direct contact.
- Reduces potential for erosion.
- Does not preclude development of site.

Disadvantages

- 354,000 cubic yards of off-site fill/soil needed for 100 ppm areas which could result in potential adverse impacts to neighboring roads over a 19 month period.

- Does not meet RCRA interim status cover requirements.

- Certain portions of the waste are below the water table. Alternative III would not substantially reduce the volume of contaminated soil in contact with ground water.

Alternative IV (20 mil PVC Liner, Sand Beds, 12-Inch Fill, 6-Inch Cover, Vegetate)

Work Items

- Cut, fill, regrade top 12 inches of existing soil to develop new contours, eliminate water pockets, promote better drainage.

- Cover area with a 6 inch layer of compacted sand.

- Install 20 mil PVC membrane liner.

- Install 6 inch layer of compacted sand over liner.

- Cover fill with 12 inch layer of off-site fill

- Cover area with 6 inch layer of top soil and vegetate.

- Additional Work:

    - Surveying to verify cuts and fills and test borings to delineate contamination

    - Install 60-inch drain to dewater swampy area in order to stabilize hide pile slopes before adding cover

    - Mobilization and demobilization of equipment

Advantages

- Reduces infiltration.
- Reduces potential for direct contact.
- Meets RCRA interim status cover requirements.

Disadvantages

- Precludes future site development on 70 acres for 100 ppm limit.

- Implementation for 100 ppm areas involves installation of 74.0 acres of synthetic membrane plus 380,000 cubic yards of fill/sand.

- Portions of the site such as the Boston-Maine railroad track ROW and buildings may be impossible to seal with a synthetic membrane. This could possibly reduce the environmental effectiveness of Alternative IV.

Alternative V (6-Inch Cover, Vegetate, Deed Restrictions)

Work Items

- Regrade top 12 inches of existing soil to develop new contours, eliminate water pockets and promote better drainage.

- Cover with 6 inches of backfill and establish vegetation.

- Obtain deed restrictions.

Advantages

- Minimal disruption to local businesses and the community.

- Readily implementable.

- Eliminates potential exposure due to remote possibility of heavy metal migration.

- Does not preclude development of site.

Disadvantages

- Does not meet RCRA interim status cover requirements.

- Increased infiltration compared to 6 inch clay, 24 inch clay or impervious liner.

- Certain portions of the waste are below the water table. Alternative V would not substantially reduce the volume of contaminated soil in contact with ground water.

Alternative VI (Construct RCRA Landfill)

Work Items

- Construct a RCRA landfill including double liners and leachate detection system.

- Remove 1,000,000 cubic yards of soils and/or hide piles and replace with new fill.

- Truck backfill from off-site.

- Additional Work:

  - Surveying to verify cuts and fills and test borings to delineate contamination

  - Install 60-inch drain to dewater swampy areas in order to stabilize hide pile slopes before adding cover

  - Mobilization and demobilization of equipment

Advantages

- Meets most stringent RCRA requiements.
- Surface contact with the materials is eliminated.
- Reduces potential for surface water contamination and infiltration.

Disadvantages

- Potential for odor release during excavation and transport would require additional studies such as a health and safety plan, monitoring plan and contingency plan.

- Practicality is highly questionable due to availability of fill and logistics.

- Precludes development on 13.6 acres used for RCRA facility.

- Provides little additional benefit to environment and public health compared to Alternative V and backup ground water metal treatment implementation.

- Severe disruption of local businesses and the community due to on-site activities

- 1,000,000 cubic yards of cover and backfill needed for 100 ppm areas which could result in potential adverse impacts to neighboring roads over a 46 month period.

Alternative VII (Consolidate, Cover with
30-Inch Soil/Fill, 20 mil PVC Liner, Backfill)

Work Items

Excavate and Consolidate with Backfill

PX Engineering	9,900 cy
Chromium Lagoons	107,300
Janpet Associates	173,600
Wedge Areas	37,900
Arsenic Pit	125,100
Stafford	5,800
	459,600 cy

- Excavate all areas above and relocate to East and East-Central Hide area.

- Backfill excavated areas with off-site fill.

- Install 60-inch drain to dewater swampy areas in order to stabilize hide pile slopes before adding cover.

- Cover areas with 20 mil PVC liner, 24 inch fill and 6 inches of topsoil.

Advantages

- Off-site trip generation results from backfill operations.
- Unrestricted future development on excavated portions of the site.
- Reduced potential for direct contact and erosion.
- Future maintenance surveillance is easier.

Disadvantages

- 700,000 cubic yards of fill needed for 100 ppm areas which could result in potential adverse impacts to neighboring roads over a 50-month period.

- Potential for contaminant release during excavation and relocation would require additional studies such as a health and safety plan, monitoring plan and contingency plan.

- Roads may require replacement.

- Dewatering difficulties could be encountered before consolidation of material.

- Little additional protection of the environment or public health.

- Traffic control, truck scheduling and noise would present a severe disruption to local businesses and the community.

- Precludes development on 15 acres used for consolidation of wastes.

Alterantive VIII (Consolidate, Cover with
30-Inch Soil/Fill, 20 mil PVC Liner No Backfill)

Excavate and Consolidate Without Backfill

PX Engineering	9,900 cy
Chromium Lagoons	107,300
Janpet Associates	173,600
Wedge Areas	37,900
Arsenic Pit	125,100
Stafford	5,800
	459,600 cy

- Excavate all areas above and relocate to East Central Hide Pile area.
- Cover hide pile with 20 mil PVC liner, 24 inches of fill and 6 inches of topsoil.

Advantages

- Minimum off-site trip generation compared to Alternative VII, therefore, significantly less disruption to local businesses and the community.

- Cost is approximately 50 percent less than Alternative VII.

- Unrestricted future development could begin immediately on excavated portions of site.

- Would provide town with area to deposit nonhazardous fill or construction debris.

Disadvantages

- Potential for contaminant release during excavation and relocation would require additional studies such as a health and safety plan, monitoring plan and contingency plan.

- Dewatering difficulties could be encountered before consolidation of material.

- Would leave open holes up to 15 feet deep on-site.

- Roads might require replacement.

- Precludes development on 15 acres used for consolidation of waste.

Alternative IX (Fence and Deed Restrictions)

Work Items

- Fence localized contamination.
- Provide deed restrictions for future site development.

Advantages

- Prevents direct contact with localized contamination.
- Readily implementable.
- Does not preclude development of site.
- Minimal disruption to local businesses and the community.

Disadvantages

- Does not meet RCRA interim status cover requirements.

- Certain portions of the waste are below the water table. Alternative IX would not substantially reduce the volume of contaminated soil in contact with ground water.

Alternative X (Cover Areas in Top 2 Feet Greater Than Either 300 ppm As, 1,000 ppm Cr or 600 ppm Pb With 30 Inches Fill/Soil)

Work Items

- Cut, fill, regrade top 12 inches of existing soil to develop new contours, eliminate water pockets, promote better drainage.

- Cover area with 24-inch layer of off-site fill.

- Cover area with 6-inch layer of topsoil and vegetate.

Advantages

- Prevents direct contact with potentially hazardous surficial metal concentrations.

- Readily implemented.

Disadvantages

- Does not meet RCRA interim status cover requirements.

- Certain portions of the waste are below the water table. Alternative X would not substantially reduce the volume of contaminated soil in contact with ground water.

- 200,000 cubic yards of fill needed which could result in potential adverse impacts to neighboring roads over a 10-month period.

ALternative XI (Cover Areas in Top 2 Feet Greater Than Either 300 ppm As, 1,000 ppm Cr or 600 ppm Pb with 6 Inches Fill/Soil)

Work Items

- Cut, fill regrade top of existing soil to develop new contours, eliminate water pockets and promote better drainage.

- Cover with 6 inches of soil and establish vegetation.

- Obtain deed restrictions.

Advantages

- Less disruption to local businesses and the community.

- Readily implementable.

- Eliminates potential exposure due to remote possibility of heavy metal migration.

- Does not preclude development of site.

- Limited excavation and relocation of New Boston street ditch bordering PX Engineering.

Disadvantages

- Does not meet RCRA interim status cover requirements.

- Increased infiltration compared to 6 inch clay, 24 inch clay or impervious liner.

- Certain portions of the waste are below the water table. Alternative XI would not substantially reduce the volume of contaminated soil in contact with ground water.

Transportation

Any off-site disposal alternative or backfill operation will generate off-site vehicular trips. A November 1983 environmental impact report jointly prepared for Sheehy Industrial Park by GHR Engineering, Goldberg-Zoino and Associates (GZA), and William F. Hicks identified the Woburn Industriplex Area "as a primary traffic problem area requiring substantial attention." In addition, "Mishawum Road suffers from heavy traffic congestion throughout the day...(which) results from a bottleneck at the intersection of Commerce Way/Mishawum Road and ramps off Interstate 95 (Route 128)." To mitigate traffic problems in the area, emphasis was placed on vanning/carpooling, staggered work hours and flex-time.

I-93 in the vicinity of the site presently has a Level Of Service (LOS) of between C and D. LOS C is still in the zone of stable flow, but speeds and maneuverability are closely controlled by high volumes. Most of the drivers are restricted in their freedom to select their own speed, change lanes or pass. LOS D approaches unstable flow, with tolerable operating speed maintained though restrictions to flow may cause substantial drops in operating speeds. Drivers have little freedom to maneuver at LOS D and comfort and convenience are low.

Projected truck access would be from Route 38 via Merrimac Street or Route 129 via New Boston Street or Commerce Way - Mishawum Road. All three routes have traffic congestion with Route 38 probably having the least but running through the most residential areas. The most desirable routes to minimize residential traffic and provide direct access to major highways is Route 129 and Commerce Way - Mishawum Roads. However, the Sheehy report stated the Route 129 Level of Service (LOS) is E and F and the Commerce Way - Mishawum Road intersection has a F LOS. LOS E represents unstable flow with speeds in the neighborhood of 30 mph. LOS F describes forced flow operation with frequent stoppages due to downstream restrictions. In the extreme, both speed and volume can drop to zero at LOS F. Thus, the only practical alternative to handle off-site trips generated by on-site activities would involve off-peak operation.

It is estimated by a local contractor that an average of 1,000 yards per workday of off-site fill could be trucked on-site. An estimate of the implementation time necessary for each of the alternatives is presented below:

Alternative	Soil/Fill/ Clay (c.y.)	Implementation Time (Workdays)
I	380,000	380
II	380,000	380
III	354,000	354
IV	318,000	318
V	80,000	80
VI	1,000,000	1,000
VII	700,000	700
VIII	140,000	140
IX	40,000	40
X	200,000	200
XI	60,000	60

Rerouting Wetlands/Swamp Drainage

A swamp/wetlands area is located directly adjacent to and between the East and West hide piles on the north end of the Woburn site. Regardless of the remediation technique selected for contaminated soils, this area must be drained and channeled off-site.

A plan has been submitted by GHR Engineering Corporation to control runoff and attenuate stormwater collection for the Sheehy property directly north of the site. In the Sheehy development plan, stormwater retention and runoff control are provided by a series of two ponds. The south pond dike will be located approximately 110 feet north of the northern site boundary. The discharge from the dike is controlled by two 24-inch RCP culverts. As currently designed, the discharge from these culverts would drain into the wetlands now established between the hide piles.

As a result of the Sheehy development stormwater retention design, it is possible to drain the wetlands and provide adequate stormwater equalization. A channel would drain normal runoff and attenuated stormwater from the Sheehy property to currently constructed flood control drainage structures on the southern portion of Industriplex 128.

In the environmental impact report for the Sheehy Industrial Park, three alternatives were proposed and are illustrated on Figure 4-4. The most westerly drainage system would flow into the New Boston Street drainline system, which discharges at a point well south of the Woburn site. The second system would drain between the hide piles and through the contaminated site to

75-9

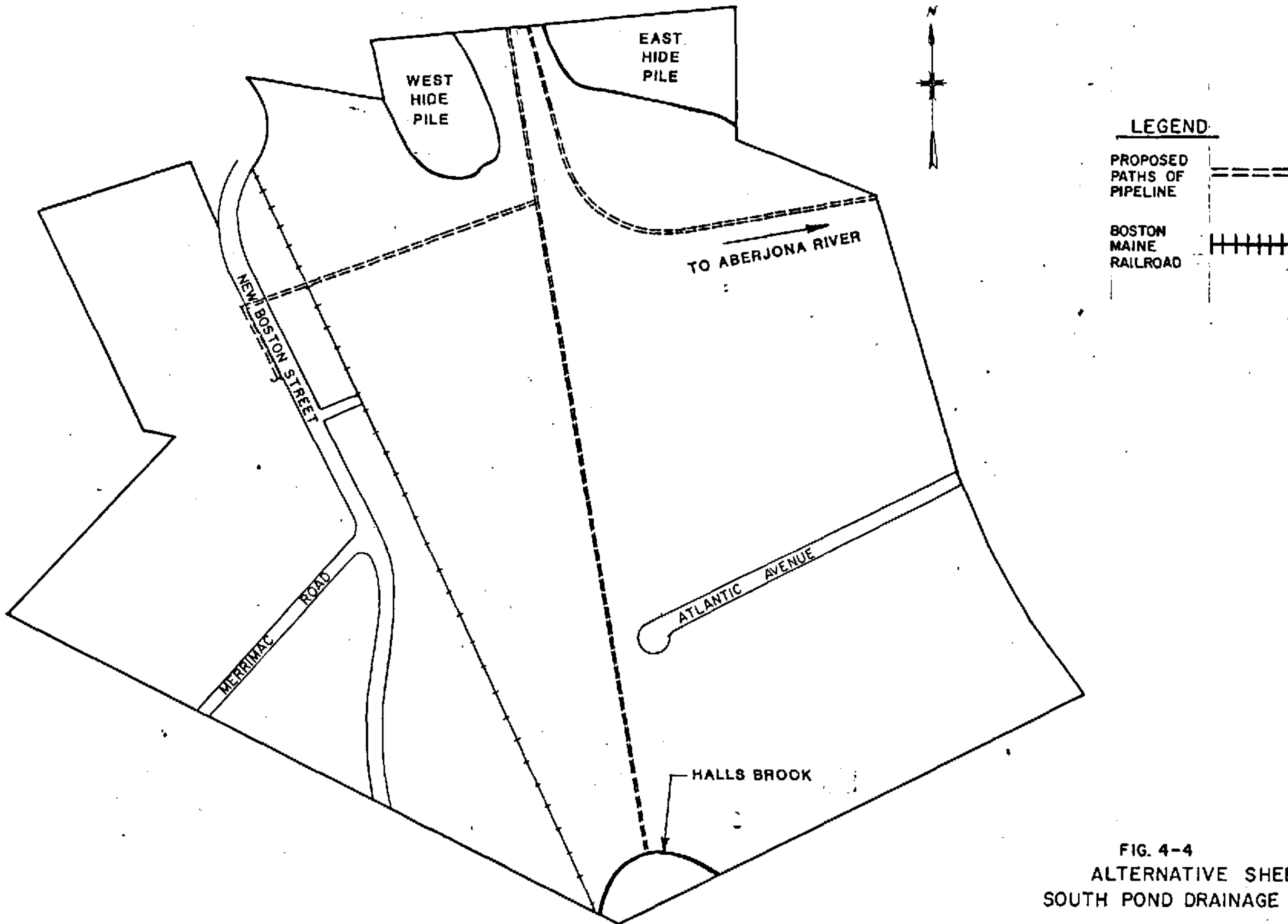


FIG. 4-4
ALTERNATIVE SHEEHY
SOUTH POND DRAINAGE ROUTES
SITE PLAN

SCALE: 1" = 300'

MALCOLM PIRNIE

a storage area as assumed in the original Industriplex drainage project. The third option, which does not require making extremely deep cuts for proper drainage, is to connect the South Pond discharge to the Commerce Way Drainage System, which runs north-south along the eastern boundary of the Woburn site.

The advantages and disadvantages for each of the three alternative routes are summarized in Table 4-2.

The three most important considerations in the selection of a drainage connection from the Sheehy South Pond to a completed site drainage system are:

- Minimize excavation
- Minimize contact with contaminated soils
- Sufficient capacity in the proposed drainage system for connection

Based on these criteria, installing a conduit from the Sheehy South Pond outlet to the Commerce Way drainage system appears the most desirable alternative. The relief is such that deep cuts (>10 feet) are not required as would be in the connection to the New Boston Street ditch. In addition, it is stated in the Sheehy Development Draft Environmental Impact Report that "...the effect of this connection is to direct south pond drainage around the Hall's Brook storage area and bring it directly to the Mishawum Road culverts." Therefore, the chief advantage to this alternative is decreased opportunity for drainage to come in contact with contaminated soils.

There is no negative impact resulting from the directing of south pond outflow directly to Mishawum Road rather than passing it through the Hall's Brook storage area, since elevated headwater at the Mishawum Road culvert would cause drainwater to back into the Hall's Brook storage area. It functions, therefore, as a surge chamber holding excess storm flow at peak times, as intended. Instead of the Hall's Brook storage area being filled from the north by early, nonpeak stormflow, it would not fill until it was needed for stage at peak flow time.

Accordingly, "the direction of the south pond outflow to the Commerce Way drainage system is the preferred alternative in order to minimize contamination potential and to maximize desirable hydraulic response." Our calculations indicate that excess storage capacity will exist in the Phillips Pond area even assuming the most limiting scenario.

TABLE 4-2

ADVANTAGES AND DISADVANTAGES OF ALTERNATIVE DRAINAGE ROUTES

Route	Advantages	Disadvantages
West to New Boston Street Ditch	Relatively short connection (1,200 feet)	Deep cut required for gravity flow
		Capacity of drainage ditch along New Boston Street and culverts may be insufficient
South to Hall's Brook Storage Area	Capacity of drainage system sufficient (as originally designed)	Relatively long connection (2,500-3,000 feet) Most contact with contaminated soil of three options
East to the Commerce Way Drainage System	Connection of moderate length (1,500 feet)	Partial contact with contaminated soils
	Capacity of drainage system sufficient for attenuated flow conditions	

Based upon calculations of the anticipated flow from the Sheehy South Pond outlet under maximum pond elevation conditions, a 60-inch diameter polypropylene pipe at a 4 percent slope should be sufficient to gravity drain the outflow from the pond to the Commerce Way drainage system. It is anticipated, based upon the Sheehy EIS, that the attenuated flow from the pond will not surcharge the Commerce Way system as currently designed. Surface water management at the Woburn site is considered throughout the evaluation of alternatives as an integral component of remedial actions that address the hide pile deposits, contaminated soils, and general overall site management. Since the drainage system is the sole alternative required specifically for surface water control, no functional analysis will be presented for surface water control alternatives.

4.5 Cost Effective Ranking for Contaminated Soils Alternatives

Table 4-3 summarizes the functional analysis, capital costs, O&M costs, total implementation costs and recommended ranking of the selected alternatives for contaminated soils. Ranking rationale is weighted evenly between the functional analysis values derived in Section 4.4 and the total implementation costs. Total implementation cost summaries can be found in the attached appendix.

In order to distinguish differences between cost and functional analysis values, the following descriptive terms are used in the ranking rationale:

- "Highest" indicates a 1 ranking
- "High" indicates a 2 or 3 ranking
- "Good" or "Moderate" indicates a 4, 5, 6 or 7, or 8 ranking
- "Low" indicates a 9 or 10 ranking
- "Lowest" indicates a 11 ranking

The ten alternatives were ranked from the highest (1) to lowest (11) functional values. Likewise, total implementation costs were ranked from most expensive (1) to least expensive (11). The descriptive terms were then applied to the two criteria which resulted in the recommended ranking summarized below:

1. Alternative X (cover areas in top 2 feet greater than either 300 ppm As, 600 ppm Pb or 1,000 ppm Cr with 30 inch fill/soil)

2. Alternative III (24-inch fill, 6-inch cover, vegetate)

3. Alternative V (6-inch cover, vegetate, deed restrictions)

4. Alternative XI (cove areas in top 2 feet greater than either 300 ppm As, 600 ppm Pb or 1,000 ppm Cr with 6 inch fill/soil)

5. Alternative VIII (consolidate, cover with 30-inch fill, no backfill of excavated areas)

6. Alternative IX (limited excavation and relocation of ditch along New Boston Street, fence, deed restrictions)

7. Alternative IV (20 mil PVC liner, 12-inch sand, 12-inch fill, 6-inch cover, vegetate)

8. Alternative I (24-inch clay, 6-inch cover, vegetate)

9. Alternative VII (consolidate, cover with 30-inch fill, backfill excavated areas)

TABLE 4-3

COST COMPARISON OF SELECTED ALTERNATIVES FROM CONTAMINATED SOILS FUNCTIONAL ANALYSIS RESULTS

Remedial Alternative/Description	Functional Analysis Value	Capital Cost	O&M Cost	Total Implementation Cost	Ranking	Ranking Rationale
I 24" clay, 6" cover, vegetate	16.8	$22.7 M	$1 M	$23.7 M	8	- Good functional analysis - High cost
II 6" clay, 18" fill, 6" cover, vegetate	14.8	$12.3 M	$1 M	$13.3 M	10	- Low functional analysis - Moderate cost
III 24" fill, 6" cover, vegetate	18.3	$ 8.2 M	$1 M	$ 9.2 M	2	- High functional analysis - Moderate cost
IV 20 mil PVC liner, 12" sand, 12" fill, 6" cover, vegetate	16.3	$11.4 M	$1 M	$12.4 M	7	- Good functional analysis - Moderate cost
V 6" cover, vegetate, deed restrictions	16.8	$ 4.1 M	$1 M	$ 5.1 M	3	- Good functional analysis - Low cost
VI RCRA landfill	13.6	$79.0 M	$1 M	$80.0 M	11	- Lowest functional analysis - Highest cost
VII Consolidate, cover with 30" fill, 20 mil PVC, backfill of excavated areas	16.7	$18.0 M	$1 M	$19.0 M	9	- Good functional analysis - High cost
VIII Consolidate, cover with 30" fill, 20 mil PVC, no backfill of excavated areas	17.2	$ 9.0 M	$1 M	$10.0 M	5	- High functional analysis - Moderate cost
IX Limited excavation and relocation of ditch along New Boston Street, fence, deed restrictions	14.8	$ 2.3 M	$1 M	$ 3.3 M	6	- Low functional analysis - Lowest cost

TABLE 4-3

COST COMPARISON OF SELECTED ALTERNATIVES FROM
CONTAMINATED SOIL FUNCTIONAL ANALYSIS RESULTS (Continued)

	Remedial Alternative/Description	Functional Analysis Value	Capital Cost	O&M Cost	Total Implementation Cost	Ranking	Ranking Rationale
X	Cover areas in top 2' greater than either 300 ppm As, 600 ppm Pb or 1,000 ppm Cr with 30 inch fill/soil	18.8	$ 5.3 M	$1 M	$ 6.3 M	1	- Highest functional analysis - Moderate cost
XI	Cover areas in top 2' greater than either 300 ppm As, 600 ppm Pb or 1,000 ppm Cr with 6 inch fill/soil	16.3	$ 3.0	$1 M	$ 4.0 M	4	- Good functional analysis - Low cost

10. Alternative II (6-inch clay, 18-inch fill, 6-inch cover, vegetate)

11. Alternative VI (RCRA landfill)

GLOSSARY

ACFM	-	Actual Cubic Feet per Minute
BOD	-	Biochemical Oxygen Demand
cfm	-	cubic feet per minute
cm	-	centimeters
C/Stl.	-	Carbon steel
DEQE	-	Department of Environmental Quality Engineering
EPA	-	Environmental Protection Agency
F	-	Fahrenheit
$FeCL_2$	-	Ferrous Chloride
GAC	-	Granular Activated Carbon
gph	-	gallons per hour
gpm	-	gallons per minute
H_2O_2	-	Hydrogen Peroxide
H_2S	-	Hydrogen Sulfide
M	-	Million
MDC	-	Metropolitan District Commission
mil	-	0.001 inch
N/A	-	Not Applicable
NCP	-	National Contingency Plan
ND	-	Nondetectable
O&M	-	Operation and Maintenance
PAC	-	Powdered Activated Carbon
pH	-	negative logarithm of the hydrogen ion concentration
ppb	-	parts per billion
ppm	-	parts per million
PVC	-	Poly Vinyl Chloride
RBC	-	Rotating Biological Contactor
RCRA	-	Resource Conservation and Recovery Act
S	-	Storage coefficient
SDWA	-	Safe Drinking Water Act
sec	-	second
sf	-	square feet
SNARL	-	Suggested No Adverse Response Level
SO_2	-	Sulfur Dioxide
SPDES	-	State Pollution Discharge Elimination System
S/Stl.	-	Stainless Steel
T	-	Transmissivity
TTP	-	Total Priority Pollutants
UIC	-	Underground Injection Control
VOC	-	Volatile Organic Compound